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GENDER EQUALITY AND EDTECH: WHAT ARE THE BARRIERS AND ENABLERS TO ENHANCE EQUITY IN AND THROUGH EDTECH?

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ABSTRACT

This background paper reviews the literature-based evidence, a set of household surveys and a series of practice-based interventions in relation to educational technologies (EdTech) and gender in the context of Low- and Middle-Income Countries (LMICs), with focused research in Kenya, Sierra Leone and Tanzania.

We illustrate that the main categories of factors to consider to design EdTech interventions to support girls' education are the access, use and content of EdTech. We introduce a framework that summarises the findings of this background paper and that can be used to consider these evidence-based factors throughout EdTech interventions. To design inclusive EdTech interventions to support girls' education these factors need to be explored through gender, political economy and intersectional lenses.

The evidence for EdTech to support girls' education tends to point to barriers and enablers that need to be considered to design inclusive and egalitarian EdTech interventions (these are summarised in the framework introduced in Page 44). For example, in relation to the access of EdTech, we found that a barrier to inclusive and equitable quality education for all was that girls tended to be less likely than boys to own or be able to access mobile devices in LMICs. We also found that an enabler to improve EdTech access was to use EdTech for nudging and changing inequitable beliefs, although this needs to be carefully considered within context.

There are barriers that need to be considered for all EdTech interventions aiming at supporting girls' education in LMICs. These are barriers related to reaching the most marginalised girls with EdTech, for example by ignoring political economy factors or the need for additional support for marginalised children (e.g financial, health or social support); neglecting to collect gender data throughout EdTech intervention; and disregarding the role of contextual inequalities, intersectionality and gender norms in supporting egalitarian learning through EdTech. While these factors are challenges for all educational interventions to some extent, there is a particular risk that without careful consideration, EdTech interventions could exacerbate existing 'digital divides' and increase inequity.

There are enablers that have shown significant potential to support girls' education through EdTech, both directly and through addressing the barriers. These are the use of co-design practices to improve the inclusivity, impact, contextualisation and sustainability of EdTech interventions; the application of holistic approaches to consider the interconnected realities of reaching and impacting children (for example by collaborating and engaging with diverse stakeholders); the inclusion of context and political economy analysis with data related to gender and system-level dimensions of equity to improve the contextualisation of EdTech interventions; and, the disaggregation of data by characteristics relating to inequalities and marginalisation to improve the efficacy and equity of EdTech interventions.

To create inclusive educational improvements in girls' education through EdTech, interventions need to pay significant importance to three cross-cutting themes, namely sustainability, contextualisation and intersectionality. This needs to be done by considering how to create sustainable impact by defining the direct and indirect actions that could be taking place once EdTech interventions are finalised, and by recognising that there is no silver-bullet practice for EdTech design as any EdTech intervention can only lead to positive impact when designed with built-in approaches for local contextualisation. Adopting an intersectional lens could be particularly useful to evaluate potential gender inequalities in a given context, for example by exploring how gender intersects with poverty, disability, ethnicity, religion, among other socioeconomic indications, in a specific region. However, at present, this level of attentiveness to context is rare in most EdTech evaluations.

The main findings from the data in household surveys reveal that across Kenya, Sierra Leone and Tanzania, the ownership of mobile phones is significantly higher than television or radios. While ownership is high there are notable differences in both ownership and use of different types of technology between male and females in all three countries. When it comes to mobile phones, affordability around the use of mobile internet, for example, is a barrier that extends to both males and females but affects the latter significantly more. While a gender divide exists, some of the largest differences in the use of technology relate to characteristics typically relating to marginalisation (e.g.

location, poverty, education). These intersecting factors when intersected with gender create a greater barrer to the use of technology for females, compared for males.

A series of design considerations are presented in this background paper - these are promising and practice-based indications (identified in well-established EdTech interventions in Kenya, Sierra Leone and Tanzania) that could be explored to improve the gender equity and inclusion of EdTech interventions. The use of digital personalised learning and the development of Artificial Intelligence (AI) algorithms using local data can help ensure that adaptivity and feedback are appropriate for the diversity of learners' levels and backgrounds. The application of co-design practices can help promote uptake, by ensuring that initiatives are culturally appropriate, and including girls in the process may make the contents more relatable and engaging. Gender-responsive pedagogies may be particularly promising, but there is a gap in terms of research in the context of EdTech, and a need for more support for teachers more generally. The implementation of holistic approaches - which take a broader focus than just the educational intervention, to help address the related social and economic barriers - has also been shown to be effective, and the inclusion of digital literacy capacity-building is also key as part of EdTech interventions.

Keywords

Gender, girls education, equity, technology, ICT, EdTech, low- and middle-income countries (LMICs)

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Abbreviations and acronyms

AI	Artificial Intelligence
ASAL	Arid and semi-arid lands
CAL	Computer-assisted learning
CAMFED	Campaign for Female Education
CCT	Conditional cash transfer
EdTech	Educational technology
GEC	Girls Education Challenge
ICT	Information and communication technologies
IRI	Interactive radio instruction
LMICs	Low- and middle-income countries
OLPC	One laptop per child
NGO	Non-governmental organisation
RTP	Radio Teaching Programme
SMS	Short message service
TIE	Tanzania Institute of Education
TPD	Teacher professional development
TSC	Teaching Service Commission

1. Introduction

The 2030 Agenda for Sustainable Development is a global commitment to leave no one behind, and to ensure inclusive and equitable quality education for all. To realise this, transformative actions are needed to enable girls and boys to have equal access to education, to acquire the knowledge and skills they need for life, and to fulfil their aspirations. It is crucial to recognise that these actions can only lead to positive impact if considerations of gender, political economy, equity and intersectionality are integral parts of interventions targeted at improving education. Intersectional, political and structural socioeconomic inequalities amplify the barriers to educational access and school attrition, presenting challenges that need to be addressed for developing education interventions that ensure no one is left behind.

Evidence of the global state of education today tends to illustrate progress - with a crisis still remaining. For example, despite significant progress in children's enrolment in school over the past 15 years, about 259 million of children and youth were out of school in 2020 (↥UNESCO, 2022a) - and between 1995 and 2018, the percentage of countries achieving gender parity in education rose from 56% to 65% in primary education, which indicates that 75% of children of primary school age who are likely not to go to school are girls (↥UNESCO, 2020b).

The use of EdTech has long been described as having the potential to enhance educational quality, improve girls' education and increase educational access for children in low- and middle-income countries (LMICs) (↥Sperling & Winthrop, 2016). This attention has been recently amplified, as the global closure of educational institutions during the Covid-19 pandemic led to immediate discussions about how to best use EdTech to provide educational continuity in the absence of school-based teaching (↥Alban Conto et al., 2020; ↥Crompton et al., 2021). As part of these discussions, significant interest has also been placed on the importance of considering girls' education, as previous crises (i.e. including wars, natural disasters, political violence and epidemics) have often led girls to being disproportionately affected by the loss of access to school-based education (↥GCPEA, 2014; ↥Hallgarten, 2020; ↥Nicolai et al., 2015; ↥Sperling et al., 2016).

EdTech is often recognised as a means of improving children's learning outcomes in LMICs by delivering cost-effective education, over distance, at scale and personalised to children's needs (↥Hennessy et al., 2021; ↥Jordan & Myers, 2022; ↥World Bank, 2020). However, evidence has also shown that the use of EdTech can lead to negative consequences, such as exacerbating socioeconomic divides, structural inequalities and gender disparities (↥Crompton et al., 2021; ↥Jordan, 2020). To better understand how to achieve sustained and inclusive educational improvements, the use of EdTech needs to be studied using rigorous evidence and through gender, political economy, equity and intersectionality perspectives. To this end, we present a comprehensive review into the barriers and enablers of EdTech designs to improve girls' education in inclusive and equitable ways in LMICs. This report was guided by the following research questions, with a focus specifically targeted at primary and secondary education in LMICs.

How can we design EdTech interventions to improve girls' education in LMICs, when applying an equity and intersectionality lens?

- What do we know about factors that need to be considered to design an EdTech intervention to improve girls' education?
- To what extent are gender inequalities reflected in the use, access and content of EdTech?
- And, what can we learn from promising practice-based interventions targeted at improving girls' education using EdTech?

The Covid-19 global school closures provide an impetus for closer investigations into the use of EdTech to improve girls' education, and to enhance inclusive and egalitarian education in LMICs. To analyse these questions, this background paper aims to:

I. Provide a comprehensive overview of the factors influencing the design of EdTech interventions in LMICs to support girls' education from equity and intersectional perspectives;

II. Review the literature-based evidence to provide an up-to-date and comprehensive overview of the existing body of empirical research in relation to EdTech and gender in the context of LMICs;

III. Identify the gender differences in access and use of different types of technology (mobile phones, radio and television), with a focus on identifying who are the most left behind;

IV. Explore practice-based EdTech interventions to identify and reflect upon design considerations targeted at improving girls' education in LMICs;

V. Present a framework that illustrates evidence-based factors, introduced as barriers and enablers, that need to be considered to design EdTech interventions aiming at improving girls' education in LMICs.

The report comprises three components of research and analysis: (i) a literature review, with consideration of relevant evidence of factors influencing girls' and egalitarian educational access, participation and learning using EdTech in LMICs; (ii) an analysis of household surveys, with a focus on three countries, Kenya, Sierra Leone and Tanzania, conducted through an analysis of the access and frequency of use of technology with a specific focus on gender; and (iii) three country case studies, with focused research in Kenya, Sierra Leone and Tanzania, facilitated through semi-structured interviews which aimed to explore practice-based design considerations to improve girls' education using EdTech. The literature, findings and practice-based indications presented in this background paper are captured and summarised in a framework. The main objective of the framework is to present evidence-based factors, introduced as barriers and enablers, that need to be considered to design EdTech interventions aiming at improving girls' education in LMICs, through an equity, political economy and intersectional perspective.

Box 1. Key definitions

EdTech: EdTech refers to the use of information and communications technologies (ICT) within the education system, be it in ministries, schools, communities, and homes. This includes digital technologies as well as low-tech devices such as non-digital radio and television (Hennessy et al., 2021).

Gender equality: Gender equality refers to the equal rights, responsibilities and opportunities of women and men and girls and boys (UN Women, no date). "*Gender equity may involve the use of temporary special measures to compensate for historical or systemic bias or discrimination. It refers to differential treatment that is fair and positively addresses a bias or disadvantage that is due to gender roles or norms or differences between the sexes*." (Nomoto & UNICEF, 2017, p.3).

Intersectionality: "I*ntersectionality is a concept that considers the differences between individual identities and takes into account social power structures and the social inequality that results from them*" (Bešić, 2020, p.115 - and Walgenbach (2017). As defined in UNESCO (2022, p.15) "*The literature also points to the need to recognize the importance of intersectionality, considering how gender intersects with poverty, location, disability, ethnicity, language, migration, displacement, incarceration, religion, sexual orientation, and gender identity and expression (Cappon, 2011; UNESCO, 2020a; UNESCO, 2020b) and how this compounds disadvantage*."

Equity: Equity can be defined as "*the absence of unfair, avoidable or remediable differences among groups of people, whether those groups are defined socially, economically, demographically, or geographically or by other dimensions of inequality (e.g. sex, gender, ethnicity, disability, or sexual orientation)*." (WHO, no date, nopage).

Marginalisation: Marginalisation is the process through which people are excluded from access to resources and opportunities. "*There are seven groups of people who have become increasingly recognised by the UN and other organisations as being particularly susceptible to processes of marginalisation, and for whom specific and focused educational actions making use of digital technologies should be taken: out-of-school youth, those with disabilities, girls and women, refugees and displaced persons, ethnic minorities and indigenous peoples, those in isolated areas, and those in informal or irregular employment*" (Unwin, 2020, p.6)

Structural inequalities: "*Structural inequality is defined as a condition where one category of people is attributed an unequal status in relation to other categories of people. This relationship is perpetuated and reinforced by a confluence of unequal relations in roles, functions, decisions, rights, and opportunities*." (ESCWA, 2015).

2. Literature review

In this section, we present a review of the existing literature related to the topic of girls education and EdTech. In order to source literature, a combination of search strategies were used. This was necessary as the focus topic does not readily lend itself to a single, concise search string. For example, 'educational technology' is an umbrella term which can potentially include a vast number of different forms of hardware and software, whether designed specifically for educational purposes or co-opted. Furthermore, studies may include information about differences related to gender without it being a core focus of the article. However, it is notable that it is uncommon for EdTech evaluations to include findings disaggregated by gender (↑Jordan & Myers, 2022). This is due in part to gender data not always being collected, but also that results are not disaggregated by gender when reporting findings. For example, in their systematic review of educational interventions focusing on impacts upon learning outcomes for girls, ↑Evans & Yuan (2021) note that approximately two thirds of the studies eligible for inclusion did not report effects disaggregated by gender. The original authors of the studies which did not were approached; half responded, and of these approximately two thirds were able to provide disaggregated data, while one third did not have the data available (ibid.). In carrying out the literature review for this background paper, we were also attentive that this is an area which is particularly prominent in the grey literature, as a result of girls education being a priority for donors and NGOs.

With these factors in mind, the search strategy combined several approaches. Academic literature searches were carried out (via Scopus) for articles which clearly address EdTech in LMICs and girls education or gender. Snowball sampling was used based on recent reviews published by the EdTech Hub, either on the topic of girls education or related literature reviews which include girls education as a theme (↑Jordan et al., 2021, ↑Kallon Kelly et al., 2020; ↑Myers et al., 2021; ↑Naylor & Gorgen, 2020; ↑Tsapali et al., 2021; ↑Webb et al., 2020; ↑Zubairi et al., 2021a; ↑Zubairi et al., 2021b). Informal recommendations from our network were also considered. Targeted searches were also undertaken for outputs from projects conducted as part of the Girls Education Challenge (GEC), as several projects included an EdTech focus (↑Girls Education Challenge, 2018). As a result, studies selected for inclusion in the literature review include two types: (i) EdTech-related interventions which specifically targeted girls or had an explicit focus on gender equity; and (ii) EdTech interventions which were not specifically targeted at addressing gender, but did discuss whether there were gender differences or not as part of their findings. It is important to note that only a relatively small proportion of EdTech studies in LMICs in general include gender, so the overall evidence base is quite limited.

In structuring the literature review, we draw upon existing frameworks which have acknowledged the intersectional nature of gender and the digital divide (↑David & Phillips, 2022; ↑Kwami, 2022; ↑Tyers-Chowdhury & Binder, 2021) and articulated the need for multiple actors and perspectives across educational systems to be considered (↑Crompton et al., 2021; ↑Girls Education Challenge, 2018; ↑Sambasivan et al., 2017; ↑Unwin et al., 2020). With this

in mind, the literature review is arranged to discuss gender equity in relation to the following factors: access to EdTech and the internet; use and impacts of EdTech; and considerations for design and content.

2.1. Access

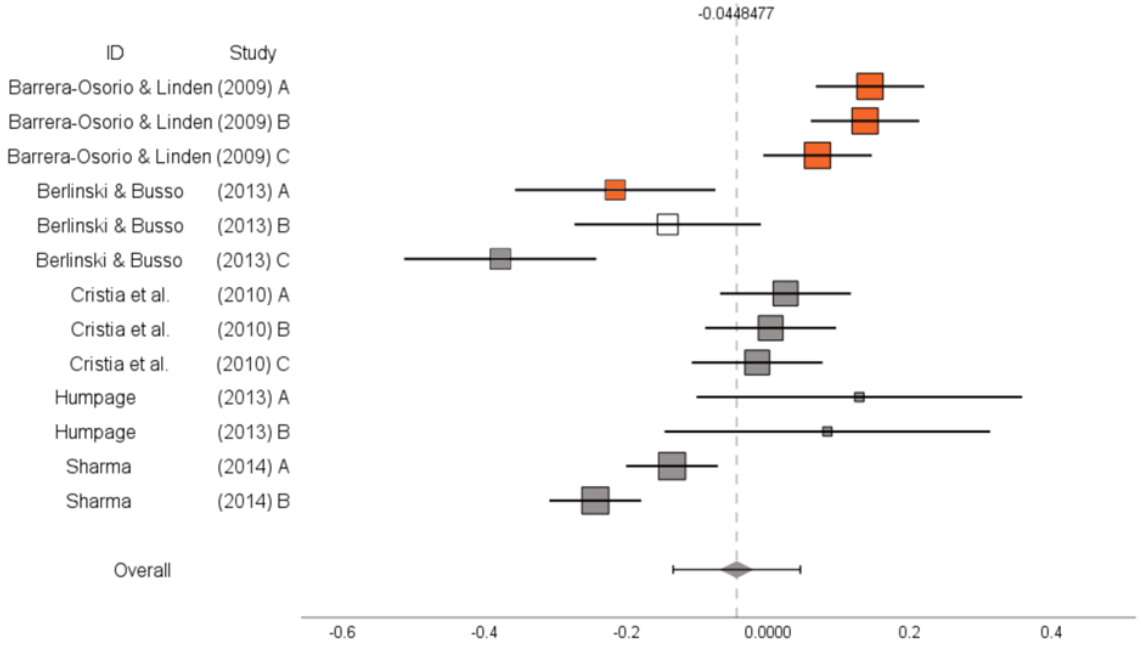
At a foundational level, a gendered digital divide exists in relation to access to technology for education. If girls are less likely to have access to technology than boys, this risks widening inequity as those who do not have access do not have the opportunity to access content or to build the digital literacy skills needed to use it effectively.

Levels of ownership of mobile devices can be substantially higher in LMICs than ownership of computers and other hardware, which is often cited as a reason why mobile learning is particularly suitable in these contexts. However, women and girls are generally less likely to own or be able to access mobile devices; for example, it is estimated that across LMICs "*165 million fewer women than men still do not own a mobile phone [...] and 300 million fewer women use mobile internet*" (↥Lindsey, 2020). This is also reflected in the levels of ownership between adolescent boys and girls, with boys also being more likely to use the internet through mobile devices than girls (↥Vodafone Foundation, 2018). Girls are frequently less likely to be attending formal education too or may be poorly served by classroom settings, and the potential for mobile learning to reach girls out of school has been identified by several authors in different contexts, such as Kenya (↥Righa, 2013; ↥Zelezny-Green, 2014) and Nigeria (↥Sarumi & Omazu, 2013). This tension can also be linked to issues of educational policy; for example in Swaziland, ↥Vilakati (2014) notes that increased ICT provision in schools is linked to a strategic goal of providing greater flexibility and equitable educational provision, while ↥Zelezny-Green (2018) noted that mixed messages in policies were preventing girls from benefiting from mobile learning in Kenya.

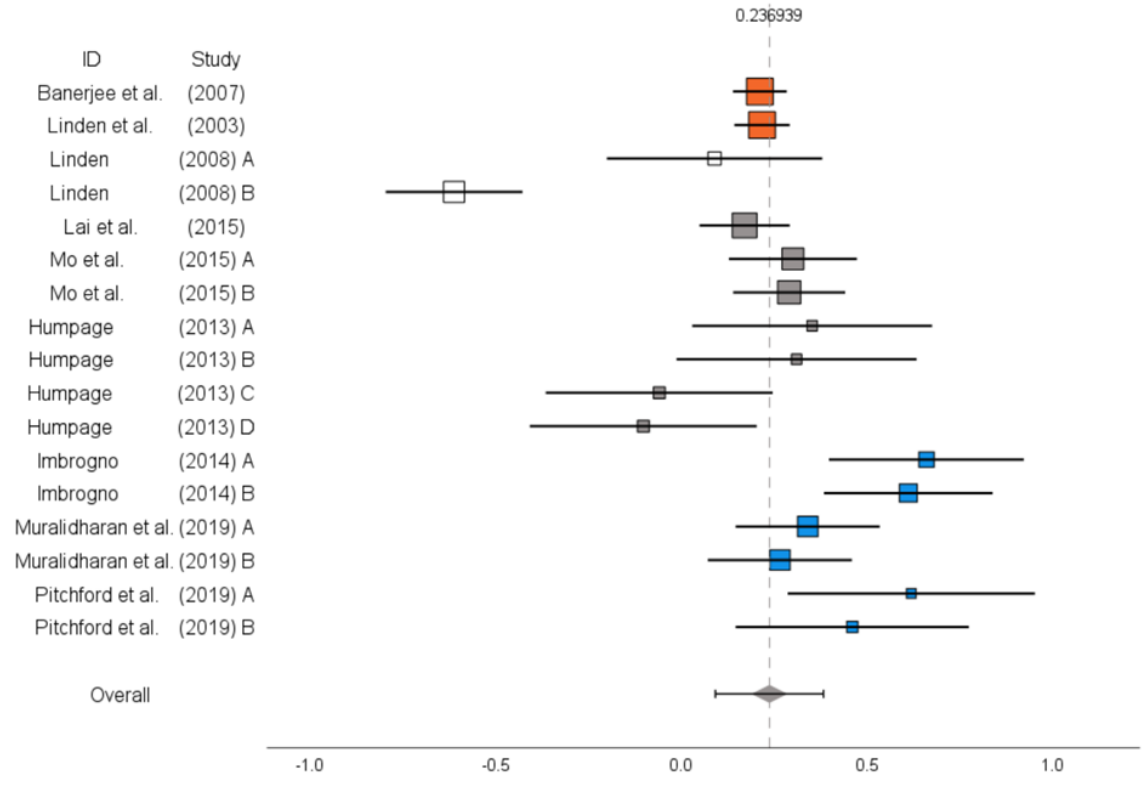
While further deployment of hardware may seem to offer a solution, it is important to note that issues of access are often associated with attitudinal biases held by gatekeepers in relation to gender and the use of technology. As a result, even in contexts with seemingly high levels of mobile device ownership, the roles of gatekeepers and the beliefs they hold can place girls at a disadvantage (↥Zelezny-Green, 2011). The importance of attending to these factors is highlighted by findings which show that EdTech interventions which principally focus on hardware deployment show low or even negative impacts for girls (↥Evans & Yuan, 2021; ↥Jordan & Myers, 2022; Box 2). As we will discuss in further detail in the sections which follow, deployment of hardware without additional support to ensure that girls and boys are equally likely to be afforded access to use it, or additional support (for example, addressing uneven levels of digital literacies as a result of different levels of prior experiences with technology) carries a risk of exacerbating gender gaps (e.g. ↥Steeves & Kwami, 2017). The differences in effect sizes between hardware-focused and software-focused interventions suggest that this may be a greater risk with the distribution of hardware.

Box 2. Effect sizes of learning outcomes - specifically for girls - associated with the EdTech-focused interventions included in a recent systematic review of education interventions (Evans & Yuan, 2021; Jordan & Myers, 2022) (figures reproduced with permission from Jordan & Myers, 2022).

Hardware-focused interventions: orange, computers; white, interactive whiteboards; and grey, OLPC.



Software-focused interventions: orange, educational computer games; white, electronic worksheets; grey, multimedia software packages; blue, personalised adaptive learning applications



2.1.1. At school and in the classroom

Attitudinal biases and gatekeeping may inhibit girls' engagement with technology for education in different ways in different contexts, both in classroom settings and outside of school. ↕Wims & Lawler (2007) cite the example of the Kenya SchoolNet survey in 2003, which reported that girls schools were less likely to make as much use of computers compared to boys schools (girls schools having a third of the computers compared to boys' schools - mixed schools are not referred to in this case), and that this reflected perceptions that computers were primarily of use for studying mathematics. Also focusing upon Kenya, the perceived link between computers and 'technical' subjects is also echoed by ↕Redempta (2012). ↕Yeba (2012) reports a study of attitudinal bias towards use of computers at schools in Central Africa - including schools in Central African Republic, Cameroon, and Congo. Lower use in schools is attributed to "*the female students' perception of themselves, ignorance, public opinion and their parents*" (Yeba 2012, p.1). In their evaluation of the BRAC-CAL programme, which saw the integration of computer hardware and multimedia resources into a sample of classrooms in Bangladesh, the findings noted that "*When gender was discussed, most respondents thought boys and girls had equal opportunity to participate in lessons and interact with teachers, but when it came to opportunities to come to the front of class and 'operate' the CAL resources, some participants thought boys are more eager than the girls*" (↕Power et al., 2017, vi).

While provision of hardware may seem to be an essential first step toward addressing the lack of access and experience using EdTech, interventions need to be attentive to issues such as these, in context, or there is a risk of widening gender inequality. For example, ↕Steeves & Kwami (2017) provide a detailed analysis of the factors which led to the discontinuation of the One Laptop Per Child (OLPC) programme in Ghana, which uncovered a substantial gender divide in the use of the devices. The gendered effects were reported to a greater extent in urban compared to rural settings, and were mainly attributed to contrasting expectations about how boys and girls should spend their leisure time. While girls were typically more constrained and expected to remain at home and assist with chores, boys had greater freedom to choose their own activities and were more likely to frequent internet cafes. This also led to gendered divides in relation to using the OLPC laptops, as girls were less familiar and lacked digital literacy skills. ↕Steeves & Kwami (2017) note that while a range of organisations exist which would have been in a position to advise on gender equity within the Ghanaian education system, none had been consulted.

2.1.2. At home and in the community

Attitudinal biases also inhibit equitable access to technology and the internet at home. In Kenya, girls were less likely to have access to technology at home than boys (30% of girls compared to 50% of boys) (↕Wims & Lawler, 2007). In their study of urban learners in India, ↕Basavaraja & Sampath Kumar (2017) report that boys were more likely than girls to have access to computers outside of school, both at home and in computer centres and cybercafes. Both genders used computers at school, but boys were more likely to make use of the internet.

This has been a critical issue recently due to the Covid-19 pandemic and school closures, which often placed parents and caregivers in a central role supporting their childrens' learning at home, either as an active facilitator of learning activities or as a mediator for access to EdTech materials, or both. As part of a survey into Covid-19 responses in Nigeria, "*while mothers supported sons and daughters almost equally, fathers were 36% more likely to assist their sons' learning than their daughters'.*" (↑Malala Fund, 2020, p.15). The survey showed that one in four girls did not receive any learning assistance at home, which represents 50% more than boys (↑Malala Fund, 2020). The report also notes that fathers were much less likely to allow girls to use the internet. While this creates a barrier when educational activities are moved online, it is important to note that this may be a combination of stereotypical roles but also the increased levels of risk for girls online (↑Stoilova et al., 2021). Girls are more likely to experience online sexual abuse, in addition to risks of cyberbullying, exposure to harmful content and mental health impacts (↑Stoilova et al., 2021).

Two research projects commissioned by the EdTech Hub sought to understand the perspectives of parents and caregivers, with particular focus on the use of EdTech and gender. In Kenya, ↑Tembey et al. (2021) found that caregivers were less likely to consider using EdTech in favour of books and tutors, and identified "*digital literacy, caregiver involvement, norms about technology for education, and intention are the most promising levers to improve access and use of educational material*." In Ghana, ↑Wolf et al. (2021) surveyed parents and caregivers educational beliefs: "*Researchers measured gender bias and found it to be high, with parents expecting boys to achieve a higher level of education than girls. Twenty-two percent of caregivers reported that they believed their son's education was more important than their daughter's. There was an association between gender bias and the time children spent in remote learning. The children of parents who had higher educational aspirations for their daughters spent more time in remote learning*." (↑Wolf & Aurino, 2021a, p.4). The findings were associated with an intervention aimed at providing behavioural nudges to parents and caregivers via SMS, which tested whether the messages impacted upon the rate of return to school, caregivers' beliefs about the value of education, and children's learning outcomes (↑Aurino et al., 2022). However, the findings present a mixed picture, and demonstrate in particular why taking an intersectional approach may be crucial. Some positive impacts were found but also negative effects, particularly for households where parents have lower education levels; "*For caregivers with no education (65 percent of the sample), the intervention only increased caregiver expectations on reaching the desired level of education, especially among girls, but reduced educational engagement and some measures of children's school enrollment and attendance*." (↑Aurino et al., 2022, p.2). Similarly, ↑Beam et al. (2022) undertook an RCT in Bangladesh with three treatment arms, to test the impacts of SMS nudges to engage with online learning and educational TV, teacher outreach, and reduction of internet costs. Significant positive impacts were found, but the effects were concentrated in higher socio-economic status households. Although this example did not specifically address gender, it also underlines the importance of considering intersectionality.

While this group of studies were undertaken as part of Covid-19 responses, the use of EdTech as a mechanism for nudging and changing beliefs has also shown potential as a way to increase girls' participation in schooling more generally. Fujii et al. (2021) conducted an intervention in Bangladesh to test whether SMS nudges could be used in conjunction with conditional cash transfers (CCTs). CCTs are established as an effective way to influence behavioural change, and one of the most frequently used approaches in educational interventions which target girls and have been shown to be highly effective (Evans & Yuan, 2021). However, there are questions about whether the cost effectiveness of CCTs can be enhanced by combining with low-cost technology such as SMS, for example. Overall, the additional SMS nudges led to a modest improvement, and were relatively cheap to implement. The findings showed that the intervention had a positive effect on school enrolment rates for girls in the higher grades at secondary school, and reduced the incidence of child marriage for girls. While CCTs are well-studied overall, there is a gap for further studies to examine their relationship with EdTech.

2.2. Use

Despite girls being less likely to have access to EdTech or the internet in many contexts, there is evidence to suggest that when girls do have access to technology for education, they may benefit to a greater extent, and may experience additional benefits (Webb et al., 2020). The main focus of this section is upon reviewing the evidence of impact upon learning outcomes, which are most frequently defined in terms of gains for literacy and/or numeracy. Although harder to define, it is also important to note that there are also more general benefits to girls. Although girls may be at a disadvantage using EdTech initially if less likely to already have experience of technology and digital literacy (Steeves & Kwami, 2017), digital literacies and skills are developed as a result of use (Ndiku & Mwai, 2016; Stanfield et al., 2018). Use of digital technology is also reported to have wider benefits in terms of increased empowerment and independence (Ferreira, 2017; Ferreira et al., 2017; Khan & Ghadially, 2010; Porter et al., 2020; Zelezny-Green, 2014).

While a group of studies do provide evidence of positive impacts on learning outcomes for girls, which will be reviewed next, it is also important to note that it is still relatively uncommon for EdTech evaluations to provide findings disaggregated by gender, which limits our understanding (Jordan & Myers, 2022). Furthermore, formal evaluation of the impact on learning outcomes has tended to focus on numeracy and/or literacy. Of the effect sizes from the Evans and Yuan dataset (introduced earlier in Box 2), the studies were equally split between maths and literacy outcomes, with similar average effect sizes overall (0.144 and 0.166, respectively).

Given the barriers often faced by girls as outlined in the previous section, the type of modality used may be important depending on the context. Considering a range of modalities is frequently recommended as a strategy to compensate for lack of access to different forms of technology (Dreesen et al., 2020), and this may be particularly important for reaching both girls and boys depending on the barriers in access that they face. As such, the discussion of studies in this section is arranged according to different forms of media involved.

2.2.1. Radio

Several studies have shown that the use of radio for educational purposes can be particularly beneficial for girls. The use of radio for education has a long history, with interactive radio instruction (IRI) being developed in the 1970s (↟United Nations Educational et al., 2004). An example which highlighted the benefit for girls can be found in ↟Nekatibeb & Tilson (2004), reporting on the use of IRI in primary schools in Ethiopia. Although it is not clear how learning gains were measured in this case, girls were reported to have gained to a greater extent than boys.

Radio has featured in responses to the Covid-19 pandemic and school closures, and three recent empirical studies affirm the potential benefits for girls and provide further insight into reasons why this may be the case. In Uganda, PEAS (Promoting Education in African Schools; ↟PEAS, 2021) adopted a model based upon the use of radio lessons combined with paper-based resources, and support from teachers via SMS and phonecalls. The study showed that girls were less likely to have access to caregivers' phones and more chores - and were significantly more likely to make use of the radio lessons and paper resources instead (↟Damani et al., 2022). While the reasons for this were not directly addressed through the study, PEAS monitoring data would suggest that this may be linked to girls spending more time at home to help with chores - radio could potentially be combined with this or part of breaks - or being perceived as a safer option for girls than phones.

In the Arid and Semi Arid Lands (ASAL) of Kenya, ↟Amenya et al., (2021) present a study of the combined use of radio lessons, reading camps, and paper resources, with a particular focus on the impact upon learning outcomes for girls. The effectiveness differed by modality - and the findings also highlight the importance of how the technology is used in practice, pointing to a key role for peer learning:

> *"Results suggest that reading camps combined with paper-based learning resources had the greatest impact on learning. The median scores for girls that used both modalities were 8.3 percentage points higher for reading and 17.6 percentage points higher for mathematics compared to girls who accessed neither. Radio lessons were not associated with higher performance in reading and mathematics, except where girls listened to the radio in groups. Qualitative data suggests that barriers to listening to radio lessons, even when girls have radios in their households, may have contributed to the limited impact of radio lessons. Reading camps were found to have mitigated against the constraints of some girls not living with literate household members. The peer-learning element of the reading camps was also a motivating factor that provided structure to girls' days through periods of prolonged school closures."* (↟Amenya et al., 2021, p.2)

In contrast to the previous study, ↟Amenya et al., (2021) report limited impact of radio lessons upon learning outcomes. The qualitative element of the study revealed that in this context, girls were less likely to have access to radios at home, because caregivers and older siblings were given priority to use the household radio.

↟Islam et al. (2022) report on an interactive radio instruction (IRI) intervention in Bangladesh, in a study context where boys tend to be prioritised for educational support (↟Hassan et al., 2021). The study focused on delivery of audio lessons by telephone, using interactive voice response technology. Learners were assigned to one of three

groups: those who received lessons on numeracy and literacy; an 'extended' group, who received lessons on non-cognitive skills such as leadership alongside the numeracy and literacy lessons; or a control, who did not receive the lessons. Additionally, SMS were used as a means to 'nudge' caregivers into supporting their children in engaging. The study showed significant positive impacts on learning outcomes as a result of the intervention, and note that there were no significant differences between outcomes for girls and boys. However, girls in the control group scored lower than boys, so it is possible that girls benefitted to a greater extent as "*the poorer performance of girls relative to boys in absence of any intervention was overcome by the intervention*" (↕Islam et al., 2022, p.40-41).

The final radio study identified during the pandemic also reports on the impact of an IRI intervention, specifically targeted at out-of-school girls in the Balochistan province of Pakistan (↕Raza, 2022). The study was undertaken as a Covid-19 response as a part of a longer term GEC project, Leave No Girl Behind. Although the study was undertaken during the pandemic, the majority of students were extremely marginalised and had never been to school even before the closures. The initiative combined daily 45-minute radio broadcasts with kits containing hygiene resources and printed educational materials: "*The IRI was paired with three different types of remote kits: dignity kits included hygiene and sanitary items such as sanitizers, sanitary pads, soups and dental hygiene kit; learning kits comprising of supplementary learning content in the form of printed practice worksheets and stationery items and recreational kits with a range of resources to support hands-on activities such as storybooks, pictures of fictional radio characters for colouring and colour pencils. The IRI was broadcasted twice every day, a fresh learning episode in the morning and its repeat broadcast in evenings by Pakistan's national radio channel.*" (Raza, 2022, p.58). Comparison of pre- and post-test assessments suggested that the intervention had been beneficial, with gains in literacy, numeracy, civic education and indigenous craft (↕Raza, 2022).

Overall, there is a relatively large body of studies which have focused on the use of radio for education, and attended to gender. This is due in part to the 'low tech' nature of radio, as a relatively cheap and accessible medium - however, the examples also illustrate that this assumption needs to be considered in context (e.g. Amenya et al., 2021). Promising practices to enhance the effectiveness of educational radio programming include the use of peer learning to engage with lessons, enhancing interactivity through phones, and provision of social and emotional topic support in addition to foundational literacy and numeracy content. However, further research is needed to understand the most effective designs in different contexts.

2.2.2. Television

Educational television and transmitted lessons represent another use of broadcast technologies, although there are fewer studies focused on this medium than radio. Two examples of evaluations of this form have demonstrated significant learning gains for both genders, with no significant differences between boys and girls. ↕Borzekowski (2018) presents a quasi-experimental evaluation of the impact of the educational television programme Akili and Me, with pre-primary children in Tanzania. Significant gains were made by students in the treatment compared to the control group on five of seven measures spanning both mathematics and literacy, with the greatest gains in

counting skills. Gender was not found to be a significant predictor of outcomes, indicating that girls and boys benefit to a similar extent (↥Borzekowski, 2018).

↥Johnston & Ksoll (2022) present findings from a cluster randomised controlled trial of an intervention implemented in Ghana through the GEC MGCubed programme. Students in rural areas received live lessons transmitted from teachers based in Accra. Students were also able to interact with teachers, through provision of computers and appropriate software. In addition to the satellite lessons, girls also received additional support through provision of after-school lessons, although these were focused on non-academic topics such as empowerment and health. The average student age in the sample was 11 years old. Overall, boys and girls both showed significant gains in mathematics and literacy as a result of the intervention, with no significant differences associated with gender. As after school provision was made available to girls at all schools, it was not possible for the evaluation to determine whether the after school lessons contributed indirectly to the learning gains.

↥Foulds et al. (2023) report an initiative which used television as a way to specifically target support for girls education. Based on data collected between 2017 and 2019, the study focuses upon the impacts of Baghch-e-Simsim (BSS), which "*has broadcast locally produced content focused on academic skills and gender equity for young children and their families*" (↥Foulds et al., 2023, p.422). Through a large-scale survey, attitudes in relation to gender (e.g. whether it is important for boys, girls, or girls and boys to attend school) were measured, and comparisons drawn between households which engage with BSS frequently or infrequently. Across the range of topics in the survey - including in relation to education, play and sports - higher frequency of viewing was associated with more equitable attitudes.

2.2.3. Mobile devices, including SMS and apps

Related to the often higher levels of mobile device ownership in LMICs compared to computers and other hardware (Section 2.1), a number of studies have considered gender differences in relation to the educational use of apps and SMS-based communication.

The use of mobile apps for reading was a progression from the need for specific hardware and opened up the benefits of e-readers to a potentially much wider audience. ↥West & Chew (2014) report on a survey of users of the Worldreader Mobile app, across seven countries (including Ethiopia, Ghana, India, Kenya, Nigeria, Pakistan and Zimbabwe). While the impact on learning outcomes was not measured, the authors address gender differences in the analysis, and found that although more men and boys use the app, women and girls may benefit to a greater extent: "*women and girls, while outnumbered by men in terms of actual users, are significantly more engaged by mobile reading. Data indicate that female mobile readers consume more books and read more often and for longer periods of time than their male counterparts. The women surveyed also held more positive attitudes about mobile reading and reading in general than men*." (↥West & Chew, 2014, p.69).

Apps which utilise forms of personalised learning showed relatively large learning gains for girls compared to the other forms of EdTech included in the review of experimental evidence by Evans and Yuan (2021) (Box 2). ↥Pitchford

et al. (2019) conducted experiment to evaluate the impact of the use of a personalised learning app - onebillion - on tablets, by Grade 1 and Grade 2 learners in Malawi. Gender differences were a specific focus of the study. Use of the app was associated with significant gains in numeracy and literacy - with girls gaining to a greater extent in literacy. The authors note that in Malawi, gender gaps typically emerge, with girls achieving to a lesser extent than boys. They suggest that the use of the app may help prevent this, as both girls and boys who used the app progressed to a greater extent compared to a control group who received teacher-led instruction alone. The onebillion app was also one of the finalists included in the Global Learning XPRIZE, evaluated in a field trial in Tanzania, alongside four other apps (↑XPRIZE, 2019). The five apps demonstrated significant gains for learners in terms of a range of measures of literacy and numeracy; in this instance, average gains were equal across both genders (↑McReynolds et al., 2020).

The use of SMS for education has received renewed interest recently as a result of the Covid-19 pandemic and school closures. A body of research literature exists prior to the pandemic, but only a few examples provide rigorous evaluation of the impact on learning outcomes and consider gender as part of analyses (↑Jordan, in press). An example of an SMS-based intervention which specifically looked at the impact on women and girls is the evaluation of the Jokko initiative in Senegal (↑Beltramo & Levine, 2012). The Jokko initiative focused on literacy, and included the use of SMS between participants in the community. The evaluation showed that the initiative was beneficial to all, but particularly for girls and women in terms of literacy (↑Beltramo & Levine, 2012).

Shupavu291 is a mobile educational platform from Eneza Education, which operates in Kenya, Ghana and Cote D'Ivoire. Through the platform, learners are provided with curriculum-linked educational materials, quizzes, and can submit questions to teachers, via SMS (Kizilcec, & Goldfarb, 2019). A number of papers have been published based on data mining from platform usage data associated with learners in Kenya. Notably, gender was found to be a significant predictor of quiz scores, with higher scores for girls who use the app (↑Kizilcec & Goldfarb, 2019).

As part of the response to Covid-19, Young1ove conducted a rapid deployment and evaluation of the use of SMS and phonecalls in Botswana to support learners in grades 3 to 5 in numeracy. While a wide range of emergency remote education tools were used in the pandemic, and insights may not be transferable following the re-opening of schools, this study is notable in that it undertook a robust experimental design with measured learning outcomes, and commented upon gender differences. Alongside a control group, families were assigned to one of two intervention groups, receiving either SMS texts, or SMS texts plus phonecall support (↑Angrist et al., 2020a). Both interventions initially resulted in significant learning gains compared to the control group; girls on average scored higher in assessments, which the authors attribute to lower initial numeracy levels overall for boys: "*We find that girls generally perform better by over 0.30 average levels, but do not benefit more from the low-tech interventions. Rather it appears boys, who also start with lower numeracy levels, benefit more from low-tech support*" (↑Angrist et al., 2020a, p.20). This example also highlights that gender differences do not uniquely disadvantage girls, and the need to consider the gendered effects of education and technology in context; while girls may face disadvantages overall, boys may also face significant barriers (↑Jere et al., 2022; ↑Young Lives, 2021). Together with this it is

important to consider the differences which girls may face, depending on their background characteristics. For example, household data illustrates characteristics relating to location, regions and wealth can contribute to disadvantage in education and technology (↥United Nations Children's Fund & International Telecommunication Union, 2020). As such, this also underscores the importance of collecting gender data, disaggregated by background characteristics, in order to understand the nature of impacts in context.

While gains were greater for phonecalls compared to SMS, costs associated with SMS were lower. However, learning gains with SMS were not sustained over time, and the design of messaging also makes a significant difference, only being effective when using targeted instruction (↥Angrist et al., 2020b). Although this study demonstrates positive results in terms of reducing learning losses during the pandemic, it should be noted that there are also broader questions however of the extent to which emergency interventions are transferable once schools reopen. Considering a similar telementoring programme, in Kenya, ↥Schueler & Rodriguez-Segura (2021) note that providing telephone support may not be the most effective use of teachers time when schools are open.

SMS also has potential to be used alongside other forms of EdTech as part of a multi-modal approach, although there are few documented examples which focus on girls or disaggregate by gender. During the Covid-19 pandemic, there was a notable focus on the use of SMS to 'nudge' parents and caregivers to help support their children or remind learners in using educational materials provided through other media (such as radio). This point also relates to the use of nudges as discussed in Section 2.1.2.2, but is distinct in that the studies here focused on nudges alongside other content provision. See Section 2.2.1.1 for discussion of the ↥Islam et al. (2022) study, which was mainly focused on IRI but also utilised SMS to nudge caregivers to engaging. While the effect of SMS was not controlled for, the intervention was shown to be effective and reminders were regarded as playing an important role in promoting engagement.

2.3. Content and design

The third group of studies address issues related to the content and design of EdTech, and examples of what can potentially be done in practice to promote and support girls' education through EdTech. The sections focus on inclusive teaching practices, inclusive design and content, and improving the use of educational data.

2.3.1. Inclusive teaching practices

As noted in the theme of 'Access' (Section 2.1), one of the potential benefits of the use of mobile phones for educational purposes is being able to support continuity for girls when they cannot attend school - but this may need a change of stance and policies by schools and government (↥Zelezny-Green, 2014). Extra support may also be needed in order to help ensure that the most marginalised girls can benefit; for example, in the iMlango project, financial incentives were provided to the poorest families to encourage attendance in school in order to benefit from the EdTech initiative (↥Ndiku & Mwai, 2016).

There is also a role for the use of EdTech to promote learning outcomes for girls indirectly, through enhanced teacher professional development (TPD) and gender responsive pedagogy. ↑Jukes et al. (2017) report on the use of an EdTech-supported TPD initiative deployed in Kenya, utilising workshops, lesson plans and text message support for teachers, with a goal of improving literacy outcomes for learners in Grades 1 and 2. While both genders benefitted to a similar extent in terms of most of the outcome measures, girls showed significantly higher improvements in terms of spelling (↑Jukes et al., 2017). There is also potential to explicitly embed gender responsive pedagogy into TPD activities; a notable example can be found in the Education in Emergencies GEC project in Sierra Leone (↑Sankoh & Cowan, 2016).

2.3.2. Inclusive design and content

The review identified some examples of additional educational activities to provide further support specifically to girls. In addition to the satellite instruction model offered to all learners at the sample of rural schools in Ghana in the MGCubed project, after school clubs were also provided for girls, focusing on issues around health and empowerment (↑Johnston & Ksoll, 2017). In addition to radio programming and the main goals of enhancing literacy and numeracy, the EAGER project in Sierra Leone also provided girls with support from a female mentor within the community (↑Sarr et al., 2020).

The design of EdTech products is also a key opportunity to take proactive design decisions to promote gender equity. This can be addressed through positive representation in examples embedded in the content, for example. In a recent landscape review of personalised learning products, "*The majority of products also make some effort to represent racial/ethnic and/or gender diversity in use of imagery or through balanced representation of race/ethnicity/gender in user interface or content*." (↑UNICEF, 2022, p.17). ↑Barnett et al., (2018) provide a detailed example of how gender equity and representation was attended to in the example of the Pikin to Pikin Tok project in Sierra Leone (see Box 4 in Barnett et al., 2018, p17). Design decisions also need to be contextually-appropriate; for example, ↑Richter & Zelenkauskaite (2014) identified gender differences associated with learners in Ghana in terms of how learners respond after failing a task, but not in the responses from learners in Germany or South Korea. The findings here suggest that different levels of support for Ghanaian learners based on gender would be appropriate if designing feedback in an app, for example.

Inclusion of women and girls in the design of digital technology is also key. ↑Bangser et al. (2017) describes a number of examples from Tanzania, including gender equity at the educational television provider Ubongo, and how this is reflected in their programming. Digital technology can also be used effectively as a way to surface girls' perspectives on education and gain further insight. Through the SAGE GEC project with out-of-school girls in Zimbabwe, ↑Buckler et al. (2022) describe how a digital storytelling approach was used as a way to explore key events in their lives and futures, generating rich data and insight from the participants' perspectives.

2.3.3. Improving the use of data

Finally, one of the key lessons from the process of undertaking the literature review was that it is relatively rare for gender to be considered in impact evaluations of EdTech. Neglecting to collect gender data creates a significant barrier to understanding and improving educational support. The AGEE (Accountability for Gender Equality in Education) data dashboard is an example of an application of EdTech to address this gap, specifically designed to facilitate exploring data in terms of gender and intersectional factors associated with educational marginalisation (↥Unterhalter et al., 2020). Designing systems not just to collect relevant data but also easily facilitate its use in practice is a key consideration. ↥Sayibu (2022) presents a short paper about how the MGCubed project.

Data is also playing an increasingly important role in EdTech through training of AI algorithms and their use in personalised learning apps. As noted in the previous section, there is evidence that personalised learning apps can provide equitable impacts on outcomes (↥McReynolds et al., 2020) or even close gaps for girls (↥Pitchford et al., 2019). There is a critical risk of perpetuating gender divides and stereotypes through AI - as demonstrated by the amplification of biases within training data, and the typically feminised design of AI assistants (↥West et al., 2019). A recent landscape report about personalised learning apps in LMICs highlights a research gap around the biases and implications of different algorithms in this context (↥UNICEF, 2022).

3. Analysis of household surveys

In the 1990s and early 2000s the issue of digital inclusion and the digital divide - both between and within countries - by different demographic groups received widespread attention from global policy makers (↥Sharp, 2022). The measures which analyse the digital divide, however, have evolved. It is increasingly recognised that access to digital devices is not the only reason that certain groups remain unconnected. As outlined in ↥Crompton et al. (2021) disparities emerge not just in relation to digital access, but also digital freedom, literacy, pedagogies and design.

The following sections rely, primarily, on the latest data that is available from 2014 Demographic Health Survey for Kenya (↥DHS, 2014), the 2019 Demographic Household Survey for Sierra Leone (↥DHS, 2019) , and the 2015 Demographic Household Survey for Tanzania (↥DHS, 2015). These household surveys largely collect data relating to access to different types of technology (namely mobile phone, radio and television). They allow us to compare rates of access and use by gender, but also when factoring in matters relating to intersectionality (by location, wealth, age and education level) household surveys can tell us about differences amongst females. While household data is not specific to school-aged children and adolescents, they serve as a good proxy to extrapolate where the most left-behind groups are likely to be when it comes to accessing and using technology.

This section has primarily relied on household surveys for discussion. However, where information on Kenya, Sierra Leone or Tanzania was available in supplementary surveys, this has reported findings where appropriate.

3.1. Kenya

The Government of Kenya has made commendable progress in promoting digital literacy and access inclusivity when it comes to gender. The popularity of M-PESA (SafariCom's mobile money service) appears to have boosted mobile phone ownership amongst both men and women. Mobile ownership is high amongst both men (94%) and women (88%) (↑GSMA, 2022). Ownership of mobile phones is higher than that of other technological devices, especially in rural areas. The 2014 Demographic Household Survey estimated, for example, that 80% of rural households owned a mobile phone (compared to 94% of urban households). By contrast just 56% of urban households owned a television compared to 19% of rural households. And while a higher proportion of rural households owned a radio (63%), compared to 74% of urban households this is still lower than mobile phone ownership (↑DHS, 2014).

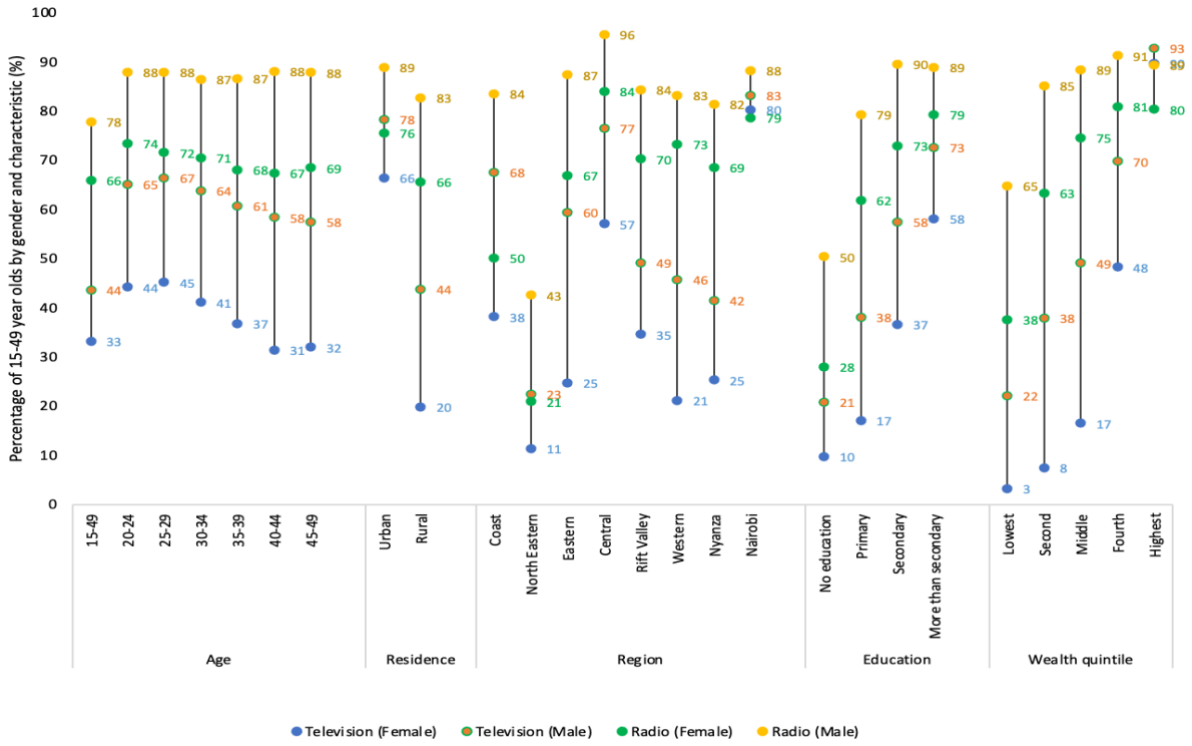
Despite progress, there are concerns about equal access to, and use over, digital devices between men and women. For example, while there is a small gender gap when it comes to the ownership of basic feature phones, the same is not true when it comes to smartphones. According to the latest GSMA gender report, 49% of adult men own a smartphone compared to 34% for women (↑GSMA, 2022). Similarly, while the gap has narrowed for mobile internet use, this is still significant amongst females (36%) and males (59%). Amongst women who did not own a mobile phone, affordability was reported as the primary barrier for 54% of women who did not own a mobile phone in 2021 (compared to 40% in 2019). Similarly, internet-related data costs were identified as a barrier to using mobile internet for both men (40%) and women (39%) who are aware of mobile internet but are impeded by the cost of its use (↑GSMA, 2022).

Specifically when it comes to use of technology, the gender digital divide in Kenya is attributed to "*discrimination, harmful social norms, the education divide, geography and lack of motivation*" (↑GSMA, 2022). One study found that only "*35% of women use advanced digital services compared to 54% of men*" (↑Dalberg, 2021). More specifically when it comes to education, less than half (48%) of women mobile owners reported mobiles helping them with their studies. This compares to 63% for all men who own a mobile phone (↑GSMA, 2022). Cultural norms can also prohibit technology use. One survey reported that 40% of rural female youth needed permission when travelling to places in order to use digital devices and services (compared to 30% for their male counterparts). Similarly female students (34%) were more likely to require permission to use digital devices compared to their male (15%) counterparts. Amongst rural female youth surveyed, 58% indicated that they get less time than other family members to use digital devices (↑Dalberg, 2021).

While ownership of radio and television is lower than that of mobile phones, data from the 2014 Kenya Demographic Health Survey is illustrative of how significant the gaps are by different characteristics. The frequency of how often these technological devices were used appeared to be correlated with structural factors relating to location, household education, wealth and location (↑DHS, 2014). When factoring in gender the differences are further exacerbated (see Figure 1). Some of the key differences are:

- The proportion of women with no education who listened to the radio at least once a week was 28% for females aged 15 to 49. For women who had at least some secondary schooling the equivalent was 79%. Having no education affects females more than men, with 50% of men with no education listening to the radio at least once a week.
- Females with no education who watch television at least once a week was the equivalent of 10% (for males with no education, the equivalent was 21%). For females with at least some level of secondary education was 58%.
- Wealth appears to be a large predictor over the use of different mediums of technology. Three percent of women from the poorest households watch television at least once a week (compared to 22% of the poorest men). In contrast 90% of women from the richest households watch television at least once a week.

Figure 1. Use of television and radio at least once a week, male and females aged 15-49.



Source: DHS (2014)

3.2. Sierra Leone

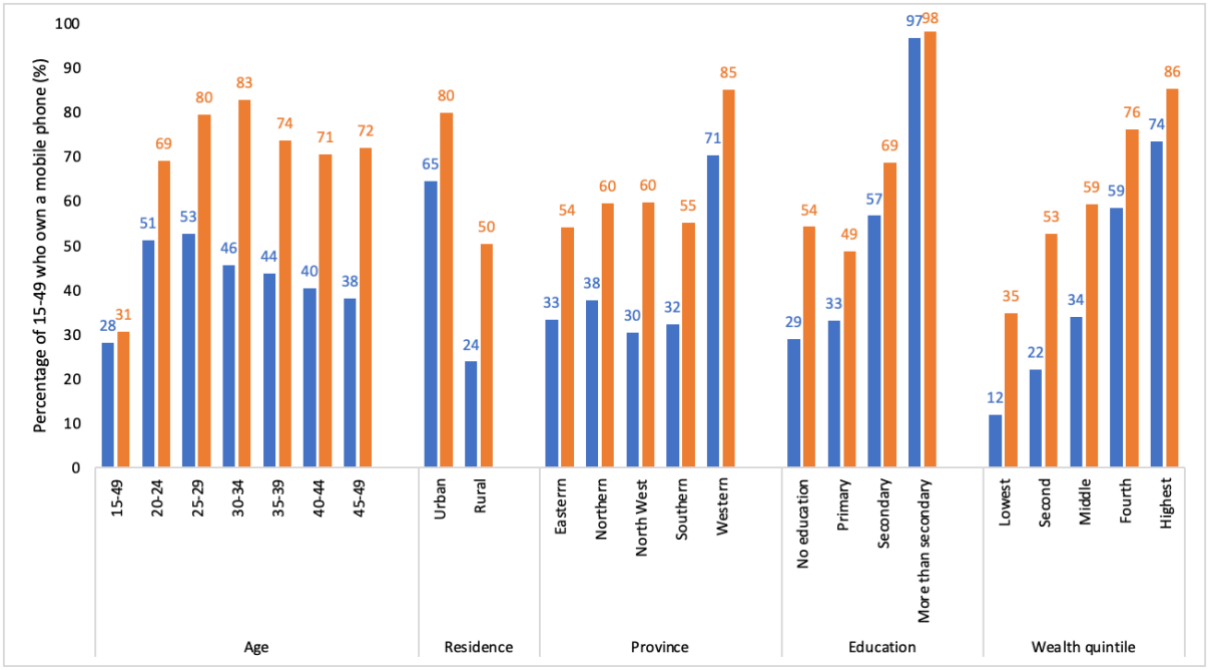
When it comes to ownership of different types of technology, household ownership of mobile phones was the highest, with 73% of households owning a mobile phone. Amongst urban households this rose to 93%, while among rural households this was the equivalent of 58%. Mobile phone ownership was followed by radio ownership, with 55% of households nationally owning a radio. And while close to 50% of urban households are estimated to own a television, this drops to just 1.8% when it comes to rural households (DHS, 2019).

By gender, an estimated 43% of women aged 15 to 49 own a mobile phone in Sierra Leone compared to 64% of men (DHS, 2019). When factoring in other demographic characteristics as they relate to age, residence, province, education and level of wealth, the gender gaps relating to mobile phone ownership further widen. Amongst some of the largest gender gaps relating to mobile phone ownership are between men (50%) and women (24%) from rural areas; men (54%) and women (29%) with no education; and men (35%) and women (12%) from the poorest households.

When looking at just women alone, characteristics relating to the level of rurality, location, level of education and wealth influence their likelihood of owning a mobile phone:

- 65% of urban women own a mobile phone compared to 24% of rural women
- 71% of women living in the Western province of Kenya own a mobile phone compared to 30% of women living in the North West province.
- 29% of women with no education own a mobile phone, compared with 97% with more than a secondary education.
- 12% of women from the poorest households own a mobile phone, compared with 74% from the richest quintile.

Figure 2. Ownership of mobile phones amongst 15 to 49 year olds (females versus males).



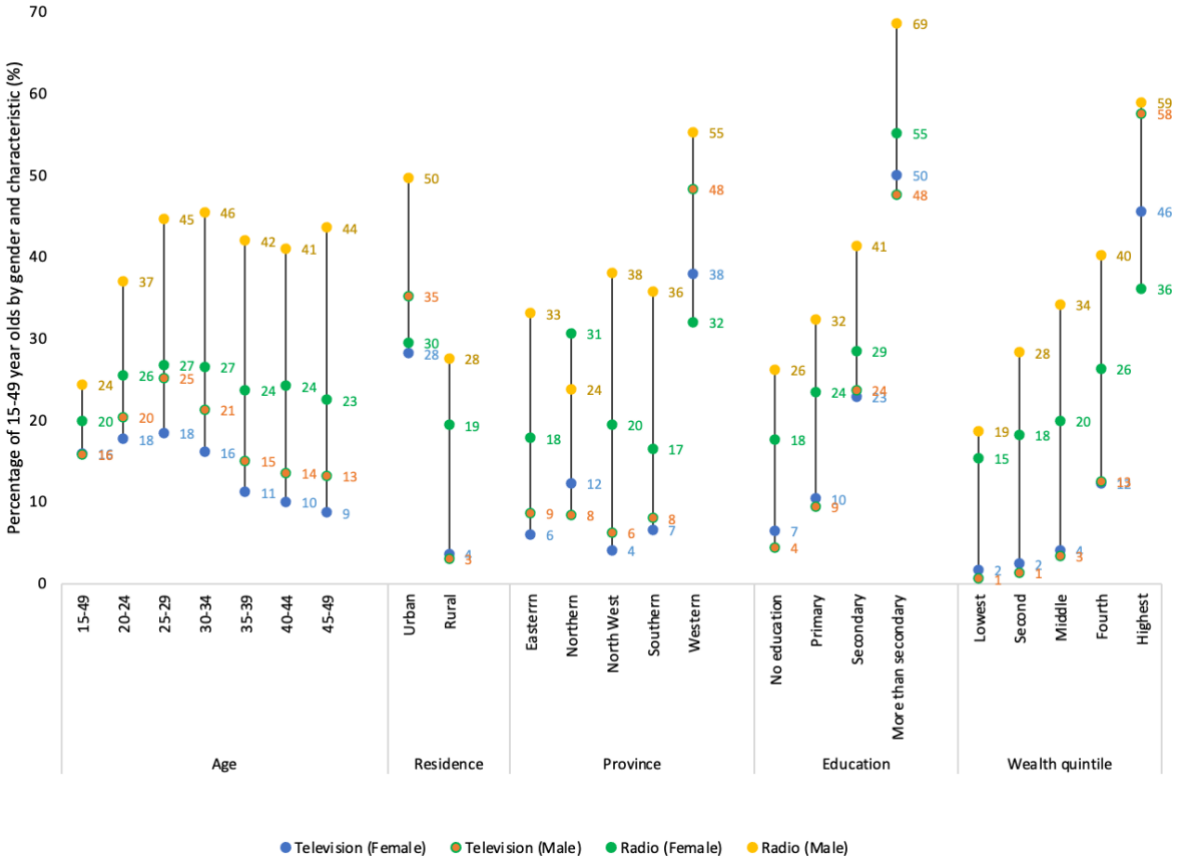
Source: DHS (2019)

When it comes to technology use, the share of females across all groups (by age, by residence, by province, by education level and by household wealth) found that females were more likely to listen to the radio than watch television at least once a week (Figure 3). However, for certain groups only a low share use these devices:

- Just 7% of women with no education watch television at least once a week, while 4% listen to the radio at least once a week. For those with more than a secondary education the equivalent is 50% and 48% respectively.
- Of females from the poorest households just 2% watched television at least once a week (compared to 46% of females from the richest households); the equivalent when listening to the radio was 1% (compared to 58% for the richest households).
- Four percent of women living in rural areas watch television once a week, compared with 28% living in urban areas. The gap is significantly lower when compared to the share of rural and urban women who listen to the radio at least once a week - 19% and 30% respectively.

Internet usage also reports large differences not just between male and female respondents, but also between different groups of women. Thirteen percent of women reported using the internet at least once over the last 12 months compared to 26% of men (↑DHS, 2019). Amongst women, internet use seems contingent on education with 77% of women with at least a secondary education having used it in the last 12 months compared to 1% of women with no education, and 4% of women with primary education. Other large differences appear predicated on the income group women come from, with 0.3% of women from the poorest households reporting having used the internet over the last 12 months, compared with 38% of women coming from the richest households. Three percent of women from rural areas report internet usage over the last 12 months, compared with 26% from urban areas (↑DHS, 2019).

Figure 3. Use of television and radio at least once a week, male and females aged 15-49.



Source: ⇡DHS (2019)

3.3. Tanzania

Mobile technology is at the heart of Tanzania's digital transformation, connecting more people in the country than any other type of communication technology (⇡GSMA, 2019). The Household Budget Survey in Tanzania found that in 2017-18, the percentage of households owning a radio equalled 43% (down from 2007 when it was 66%); 24% owned a television; and 78% of households owned a mobile phone in 2017/18 (up from 2011/12 when it was 57%) (⇡MoFP-PED, 2019).

The ownership of mobile phones has exponentially increased over a ten year period. In 2007, 1/10th of the population (or 5 million people) had subscribed to a mobile service. The numbers grew five-fold with the latest figures estimating that the number of unique mobile phone subscribers had reached 25 million, which represents just over 40% of Tanzania's total population.[1] While the uptake of mobile technology has been increasing rapidly, there is lower uptake amongst women who are less likely to use it for advanced services such as mobile internet and mobile money (⇡GSMA, 2019). When it comes to mobile phone ownership, for example, 72% of the male population owned a mobile phone compared to 52% of the female population. Mobile internet usage is significantly lower with

[1] This does not factor in that a single subscriber could be signed up to more than one network.

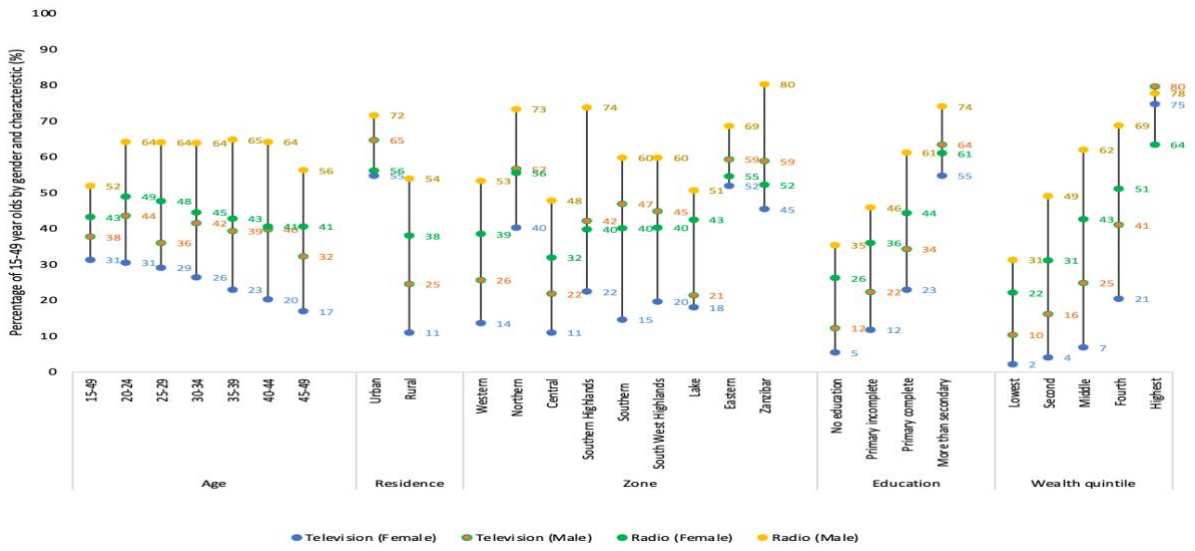
just 12% of the female phone users having used the mobile internet over the last 90 days (compared to 23% of the male population) (↑GSMA, 2019). Internet usage at large appears low, with just 8% of females aged 15-49 having reported using the internet in the last 12 months (compared to 19% of men). These averages, however, disguise how other structural factors are likely to mean certain groups of women are even less likely to use the internet. Women with no education (0.1%), from the poorest households (0.5%) and from rural areas (2%) are less likely than their female counterparts with at least a secondary education (28%), from the richest households (25%) and from urban areas (18%) to have used the internet in the last 12 months (↑DHS, 2015)

Sixty five percent of female respondents who did not own a mobile phone indicated that affordability was the single most important barrier to owning a mobile phone. This was followed by 20% who indicated their lack of digital and literacy skills was the most important barrier (↑GSMA, 2019). Similarly for women who owned a mobile phone but did not access mobile internet, 48% indicated that affordability was the most important barrier. This was followed by 27% of women who cited literacy and skills as a barrier (GSMA, 2019b).

Ownership of the radio and television is significantly lower than that of mobile phones in Tanzania. However, like Kenya and Sierra Leone the frequency of how often these technological devices were used - as reported from the 2015 Tanzania Demographic Health Survey - is contingent on structural factors which relate to location, household education, wealth and location (↑DHS, 2015). Gender further exacerbates these differences (see Figure 4). Some of the key differences are:

- When comparing between residence, just 11% of women from rural areas watch television once a week, compared with 55% of women from urban areas. Men from rural areas were more than twice as likely as women from rural areas to watch television at least once a week (25% versus 11%). The gaps between residence and between men and women in rural areas are not as extreme when it comes to listening to the radio.
- Large differences in using television as a medium of communication are also prevalent when taking into account women's level of education. Just 5% of women with no education are reported to watch television at least once a week. Women with no education are much more likely to listen to the radio (26%), although even here they lag behind females with at least a secondary education who are more than twice as likely to listen to the radio at least once a week (61%).
- Wealth appears to be a large predictor over the use of different mediums of technology. Two percent of women from the poorest households watch television at least once a week (compared to 10% of the poorest men). In contrast 75% of women from the richest households watch television at least once a week.

Figure 4. Use of television and radio at least once a week, male and females aged 15-49.

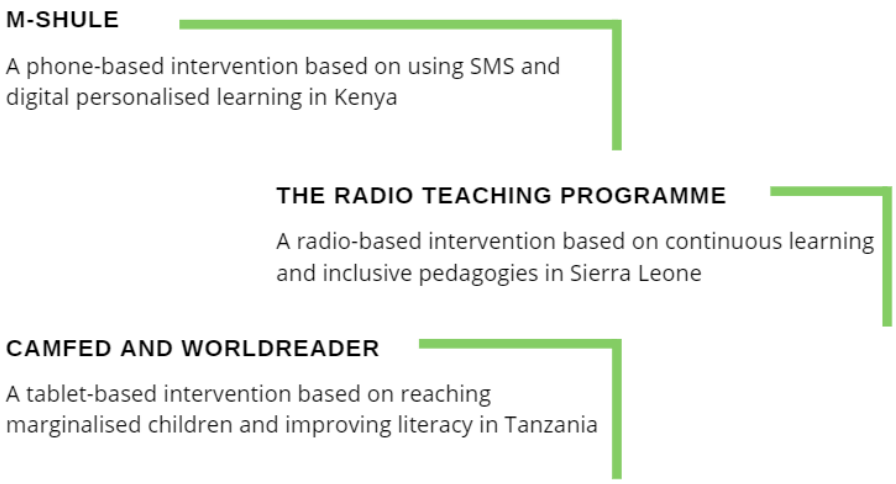


Source: DHS (2015)

4. Country case studies

The purpose of this section is to present an overview of factors that underpin the design of EdTech interventions to improve girls' education in a way that ensures equitable and inclusive learning outcomes. This was done by discussing some of the design considerations (i.e. factors that were practically implemented as part of interventions) identified in promising EdTech interventions in relation to girls' education in LMICs appearing in existing literature. We identified three EdTech interventions relating to the Kenya, Sierra Leone and Tanzania contexts (presented in Figure 5 below). The inclusion criteria for the case studies included the existing availability of evaluative studies in relation to gender-based outcomes (including preliminary evaluative studies), the objectives of the intervention targeting directly girls' education and the availability of programme managers to discuss the interventions. We also report on the experience and evidence of impact from these interventions in each country, with summary assessment results when available. Following this, semi-structured interviews were held with seven individuals across five institutions, who are working on such interventions and in the EdTech sector in these three countries. These interviews focused on the rationale and implementation of design considerations in relation to using EdTech to improve girls' learning outcomes in equitable and inclusive ways - and the content presented in this section was reviewed and validated by all the interviewees. These design considerations should be read as practice-based indications that could be explored to improve the equity and inclusion of EdTech interventions, and not as silver-bullet practices as any EdTech intervention can only lead to positive impact when designed with built-in approaches for local contextualisation.

Figure 5. Overview of EdTech interventions presented as practice-based case studies.



4.1. Kenya: M-Shule

In 2015, the Kenyan government shifted its main education priority from educational access to increased educational quality, with key priorities targeted at improving children's literacy and numeracy skills (↑Piper et al., 2016; ↑World Bank, 2018). At this time, EdTech had already been receiving attention as a promising approach to realise these objectives. This attention was amplified with the Covid-19 pandemic by putting the spotlight on the use of EdTech to improve educational access and children's learning outcomes across Kenya.

The Kenyan EdTech system is often presented as one of the most vibrant in Africa, with the majority of EdTech interventions relying on the use of personal mobile-phones and low internet connectivity (↑Otieno & Taddese, 2020; ↑Myers et al., 2021). These interventions are aligned with local realities, as Kenya has a high mobile-phone penetration and limited levels of internet access, as illustrated in Section 3.1. This is likely to change, as the government has recently committed to connecting all schools to the Internet by 2030 to enable children to have equal access to EdTech opportunities at school (↑Zaman, 2021).

Building on these realities and governmental priorities, an EdTech platform called M-shule was created in 2017. Meaning 'mobile school' in Kiswahili, M-Shule invites children, often supported by their caregivers, to access educational content and quizzes delivered through SMS on low-tech mobile phones, and without requiring an internet connection. M-Shule is based on using rule-based Artificial Intelligence (AI) to personalise the content of the SMS and quizzes to provide educational resources that are adapted to children's needs and learning levels. This technology is populated with thousands of curriculum-aligned lessons and quizz's questions that are constantly adapted to monitor, evaluate and improve learning outcomes. This technology intends to ensure that children

receive harder questions and lessons as they gain mastery and easier content if they need to further build numeracy and literacy foundational or remedial skills.

To date, the platform has reached approximately 23,000 households from 20 Kenyan counties, and has been mostly used to improve children's foundational learning, and mainly primary school children in Grades 1 to 4. In the early stages of the programme, a study illustrated that children using M-Shule for more than an hour per week saw their exam scores improve by 7% compared to non-users (n=155 caregivers and children). The study also found that 82% of caregivers using M-Shule with their children perceived that the platform had a positive impact on their children's lives. Additional findings also showed that the majority of teachers using M-Shule stated that the platform had improved classroom planning and reduced time spent on administrative tasks (↑UNESCO, 2022). M-Shule has been growing in terms of number of users in recent years including through a range of partnerships, and was recently showcased as one of 40 case studies in a UNICEF report presenting a landscape analysis of personalised learning in LMICs (↑UNICEF, 2022). A data dashboard is built into the system to allow learner progression to be monitored and evaluation of impact on learning outcomes is underway.

The M-Shule platform was designed by considering equitable practices and implemented with ambitions to improve children's learning outcomes and girls' education in Kenya. Since inception, M-Shule has been paying particular attention to ensuring that the platform does not exacerbate structural and gender-based inequalities, and two design considerations were considered key in achieving such goals - namely, the use of digital personalised learning and the creation of AI systems using local data.

4.1.1. Digital personalised learning

Definitions of digital personalised learning often vary but tend to highlight the potential of such technologies to being responsive to individual learners' needs and progress (↑Groff, 2017; ↑Major et al., 2021). A meta-analysis conducted by ↑Major et al., 2021 revealed that the use of digital personalised learning approaches in LMICs led to significantly greater learning outcomes compared to interventions that did not adapt or adjust to learners' level. In relation to girls' education, ↑Jordan & Myers (2022) have compared the relative efficacy of different types of EdTech interventions for girls, and showed that digital personalised learning had positive effects on learning outcomes for girls. Similarly, a study in Malawi evidenced that digital personalised learning platforms can be used to mitigate gender learning gaps in contexts where girls are hindered from acquiring numeracy skills at the same rate as boys (↑Pitchford et al., 2019). M-Shule is based on using low-technology devices to offer personalised learning to children - understanding why this model has been adopted in Kenya and how it has been implemented presents opportunities to better understand practical experiences related to using digital personalised learning to improve the delivery of inclusive and egalitarian learning outcomes.

Claire Mongeau, the founder and CEO of M-Shule, mentioned three main factors that have influenced the decision of using digital personalised learning to improve girls' education in Kenya. The first one is related to remedial learning - M-Shule was first created as a tool that intended to enable children to catch up on learning in case they

had to miss school. Digital personalised learning was perceived as an approach that would give children agency to access remedial learning opportunities at home, and alleviate teachers' work overload related to addressing individual learning needs in classrooms. These opportunities were particularly targeted at girls as in the Kenyan regions where M-Shule operates, girls tend to miss more school days than their male counterparts, due to factors such as menstrual health and teenage pregnancies. The rationale of using digital personalised learning was also driven by intentions to democratise home-based learning. M-Shule mostly uses children's responses to quizzes to personalise learning and address learning gaps, which can also be accessed by caregivers. This is presented as an opportunity for caregivers to better understand and support their children's learning progress and educational needs. Lastly, the decision to use digital personalised learning was also informed by the potential of such technologies to collect data related to individual academic performances and educational needs. This was considered key to improving girls' education, as the M-Shule platform could be used by teachers and policymakers to identify, evidence and tackle potential learning disparities between different groups of children.

Claire Mongeau also discussed ideas that could be seen as opportunities and challenges to implement a digital personalised learning intervention in Kenya, and in other LMICs. One of these ideas refers to the importance of contextualising EdTech interventions. M-Shule has had to adapt their intervention by considering regional differences and the diversity of the learners who could use the platform. This was implemented by hiring regional teams, facilitating collaborations with local actors and involving pedagogical experts to propose modifications to the content of the messages depending on the regions and children accessing the platform. This was also implemented to tackle gender stereotypes, for example by alternating the gender of certain characters appearing in the messages. Another implementation challenge faced by M-Shule was that caregivers tended to have concerns about their children accessing dangerous websites or social media when phones are used. These concerns were often amplified for girls, as they were often perceived by caregivers to face significant risks related to digital violence and systematic barriers to access EdTech. M-Shule implemented strategies to enable caregivers to understand and promote practices to use phones safely and inclusively, including by discussing the opportunities, differences and risks that different groups of children might face when using phones for educational purposes. Another idea mentioned by Claire Mongeau was about opportunities to apply holistic approaches to implement EdTech interventions. M-Shule have had to engage with different actors, such as teachers, community members, siblings, caregivers, policymakers, school administrators and children to explore how the intervention could be accessed, improved and made more inclusive to different groups of children. During the Covid-19 pandemic, they also had to collaborate with health workers, which highlights the importance of iteratively reflecting upon holistic approaches to implement EdTech interventions.

4.1.2. Local AI algorithm

A landscape review conducted by ↑UNICEF (2022) illustrates that personalised learning can use different approaches and technologies to tailor educational paths to learning needs. The review evidenced that out of 40 personalised learning products analysed, 24 of them used AI to customise learning by considering learners' performances. More

research and ideas are currently needed to better understand how to improve the effectiveness, accuracy and inclusivity of algorithmic approaches for personalised learning (↑UNICEF, 2022). M-Shule presents a promising case study to advance discussions related to ideas to reduce bias in the design of AI systems, as this platform is based on using local and contextual data to develop, train and test algorithms. M-Shule has been developed from scratch using Kenyan student data to train and build the model, rather than applying, and potentially adapting, an AI system developed in a different context.

Otieno Julie, the chief technology officer of M-Shule, discussed two main reasons why M-Shule decided not to use an existing AI system, and to collect local data to build and train their own algorithms. The first reason was that most AI algorithms available at the time considered and illustrated learning progress with percentages of correct answers. M-Shule decided not to adopt this idea for their platform after recognising that caregivers, children and teachers needed additional insights to understand, improve and monitor learning progress, especially by considering local inequalities, individual students' characteristics and local needs. Another reason was that M-Shule needed to train their algorithms using regional data in order to consider educational coverage and needs experienced in different regions in Kenya. This is particularly important from an equity perspective, as instances of inequalities and learning disparities are likely to take divergent forms in different regions.

Otieno Julie also discussed ideas that could trigger opportunities and tackle challenges related to implementing local AI algorithms for EdTech interventions in Kenya, and in other LMICs. The main related challenge faced by M-Shule was related to the availability and collection of data to train, test and improve the AI algorithm. To create an efficient and inclusive AI system, large datasets are regularly needed. Given that M-Shule considers regional and individual learning disparities to shape personalised learning experiences, the system also relies on children's background and school attendance data - and accessing such data can lead to issues and risks related to data privacy and security. To minimise such risks, M-Shule had to formalise partnerships with institutions that were collecting and anonymising such data. This is linked to another challenge mentioned by Otieno Julie, which is that the costs involved in building and training an AI algorithm from scratch tend to be higher than using an existing system. Lastly, another implementing obstacle faced was that the M-Shule team realised that the majority of families using M-Shule in Kenya had one phone per household and multiple children eligible to use the platform. This led the team to develop a system based on creating learners profiles where the algorithms can identify and adapt to the needs of the child using the phone.

4.2. Sierra Leone: The Radio Teaching Programme (RTP)

In 2018, the Sierra Leone government launched its flagship policy, 'Free Quality School Education', a five-year initiative announcing the government's commitment to make pre-primary, primary and secondary education free of charge for all students (↑Maada Bio, 2018). Despite Sierra Leone not having a national EdTech strategy, the government recently acknowledged - in the latest education sector plan - that technology had the potential to improve teaching and learning, reduce the gap between well-provisioned and less-well-provisioned schools, and use

data-driven approaches to better manage the education workforce (↑Government of Sierra Leone, 2018; ↑Mullan & Taddese, 2020; ↑McBurnie et al., 2021).

In response to the Ebola Crisis in 2013, multiple national radio-based education programmes were designed and implemented in Sierra Leone, examples include Leh Wi Lan[2], Pikin to Pikin Tok [3] and the Radio Teaching Programme (introduced below). When the Covid-19 pandemic started spreading in Sierra Leone, the government revisited and relaunched these programmes from the Ebola crisis - as illustrated by Minister David Moinina Sengeh[4], "*When Covid-19 emerged as a new threat to in-person teaching, we knew we could rely on radio programmes to deliver lessons and prevent students from falling behind on their education.*" (↑Sengeh, 2021, No page). This is likely to be different in a few years as the government has recently expressed ideas to build on their expertise running radio-based programmes to support the development of other types of EdTech interventions. The current intentions are to encourage hybrid models, composed of radio, television, mobile and web, and print media, to enable children to learn with the devices they have access to (↑Sengeh & MBSSE, 2021).

The Radio Teaching Programme (RTP) was first designed and implemented during the Ebola crisis and reached approximately 1 million children during school closures. The programme broadcasted lessons five days a week in 30-minute segments, and the content was based on the primary and secondary school curricula. Children were also invited to call in with questions or reflections at the end of each lesson (↑Gutierrez Bernal et al., 2021).

The RTP was again used in 2020, as a response to the Covid-19 school closures. The government implemented various measures to reach as many children as possible, and paid particular attention to targeting and impacting girls. To achieve this, the government for example partnered with national and local radio stations and directly delivered 25,000 solar- and wind-powered radios to remote communities, girls and vulnerable children. The RTP also distributed additional resources directly to girls - these included USB sticks, pre-recorded radio sessions and supplementary printed material with additional targeted educational content, that included information about reproductive health, gender equality and hygiene. The RTP lessons lasted 1 hour and were facilitated five days a week, and consisted of 45 minutes of teaching content and 15 minutes of questions and answers with children and parents. The questions and answers sessions intended to increase interactivity, assess children's learning progress and gather feedback from audiences related to how effective the lessons were, and how they could be improved. In addition to using the RTP for children's distance education, the RTP also included a programme for teachers. It aimed at enabling teachers to access lessons on teachers' professional development, and develop plans and strategies for school reopening. The remote teacher training program reached approximately 4,000 teachers working in remote and underprivileged schools (↑Gutierrez Bernal et al., 2021).

[2] More information about Leh Wi Lan can be accessed here

[3] More information about Pikin to Pikin Tok can be accessed here

[4] Minister David Moinina Sengeh is the Minister of Basic and Senior Secondary Education of Sierra Leone

Despite limited research on the RTP during the Covid-19 pandemic in Sierra Leone, two surveys captured insights on the programme's overall access and use, namely the Sierra Leone COVID-19 Impact Monitoring Survey (CIMS) and the Research for Effective COVID-19 Response survey (RECOVR) (↟Gutierrez Bernal et al., 2021; ↟World Bank, 2021; ↟IPA, 2022). As analysed in ↟Gutierrez Bernal et al., 2021, and according to the CIMS survey, 41% of children surveyed (n= 7500 households) listened to the RTP radio lessons during the Covid-19 school closures and spent an average of four hours per week on these radio lessons (↟World Bank, 2021). The RECOVR survey showed that children in 75-80% of surveyed households (n= 1,304 adults) spent time learning with their caregivers at home. Out of those who did engage in learning at home during Covid-19 related school closures, 18% of primary students and 20% of secondary students participated in the RTP programme, and 85% of students used their own school books to learn during the Covid-19 pandemic (↟IPA, 2022).

The RTP was designed with intentions to reach, impact and provide educational opportunities to girls and marginalised children during the Covid-19 pandemic. One of the core ideas of this intervention was to support girls in accessing learning opportunities that would increase their chances to go back and stay in school after the lockdown measures of Covid-19 had been lifted. To achieve this, two design considerations were considered important - namely, the use of co-design practices and the application of gender-responsive pedagogies.

4.2.1. Co-design practices

Co-design is an approach where groups involved in an intervention, for example the users of a digital tool or the participants of a programme, are invited to contribute to the intervention's design (↟Myers & Samuels, et al., 2022). Co-design is based on promoting egalitarian roles and agency as well as democratic partnerships between the stakeholders involved in an intervention – including technical teams, designers, direct or indirect participants, educators, researchers, policy makers, and groups formally known as the 'users' of a tool (↟Sanders & Stappers, 2008). Co-design is often used to collect inputs from local stakeholders to increase their involvement and agency in shaping interventions, which can be used to improve the inclusivity, contextualisation, impact and sustainability of interventions. Co-design challenges approaches based on creating interventions that are designed for individuals, and instead relies on designing interventions by the individuals who will be using or who are intending to benefit from them (↟Myers & Samuels, et al., 2022; ↟Scaife et al., 1997; ↟Sanders & Stappers, 2008). Limited evidence currently exists on how to implement this approach in practice, and on the potential suitability and impact of co-design approaches to improve girls' education in a way that ensures equitable and inclusive learning outcomes (↟Myers, 2021). The RTP presents a case study that could advance such discussion as the programme was co-designed by teachers, girls and multiple local stakeholders (↟Gutierrez Bernal et al., 2021). The teachers participated in a pedagogy development workshop, where the curricula, lessons and scripts were co-created in partnership with other stakeholders, such as the Teaching Service Commission (TSC), girls and caregivers. Girls were also invited to directly participate in radio lessons by recording educational content and proposing adaptations to the design of the lessons.

Augustine Bamie Anthony, the Sierra Leone Ministry of Education RTP manager, presented multiple reasons why co-design was used as a core approach to re-launch the RTP during the Covid-19 pandemic. The main driving idea was based on capitalising on the potential of co-design approaches to deliver inclusive, engaging and contextualised educational content to children. Building on experiences during the Ebola crisis, where the number of girls dropping out of school significantly increased due to teenage pregnancies and other gender-based factors, the programme managers decided to use co-design for ensuring the participation of girls by increasing their agency in developing the programme. Augustine Bamie Anthony also mentioned that the participation of girls in the radio sessions was used as a way to enable listeners to relate to the sessions, and to make them more engaging. Girls were invited to record radio sessions by sharing knowledge, experiences and questions as well as by delivering educational content through engaging approaches that ended up - based on the girls' ideas - including singing, drama and storytelling. The radio sessions were also adapted by inviting children to provide feedback through free calls and to participate in assessments, which were directly used to adapt the content of the upcoming sessions and to provide complementary teaching resources to children who needed it.

Augustine Bamie Anthony also discussed ideas that could be seen as opportunities and challenges to adopt co-design approaches in Sierra Leone, and in other LMICs. The first challenge was related to the support that needed to be provided to enable diverse stakeholders to directly contribute to EdTech interventions. For the RTP, this support was based on providing pedagogical training, access to curriculum-based content, technical support and supervision targeted at optimising the structure of the radio sessions. This support was considered crucial to ensure that the educational content transmitted through the radio lessons was aligned with the overall objective of the programme, which was to improve children's learning outcomes during the Covid-19 pandemic. Other obstacles were also based on exploring the extent to which the identity of the people directly contributing to the radio session should be kept confidential, and issues related to availability. Augustine Bamie Anthony mentioned that to record the radio sessions, children and teachers had to come to a specific venue, and that cultural and geographical barriers influenced the potential contribution of certain participants, and especially girls, children living in remote areas or facing severe structural inequalities.

4.2.2. Gender-responsive pedagogies

Pedagogy is often understood as the methods, theories and practice of teaching and learning (↕Alexander, 2008). Providing professional development opportunities and pedagogical support to teachers can play a pivotal role in improving children's learning outcomes in inclusive and egalitarian ways. As illustrated by ↕Zubairi et al. (2021), referencing ↕Donnelly (2015), "*As the general understanding of marginalisation and diversity develops over time — and as learner populations become more diverse — teachers require continued teacher professional development (TPD) on inclusion*" (p.21). In their systematic mapping review, ↕Hennessy et al. (2021) illustrated that there is a limited number of studies considering TPD and technology to support marginalised children in LMICs, such as girls, children from remote communities, ethnic minorities, children living in conflict situations, and orphans. Alongside the crucial necessity of designing contextualised TPD opportunities, evaluating teachers' needs continuously and

assessing the diversity of learning needs with holistic approaches, the application of gender-responsive pedagogies can also be used to improve issues related to exclusion and inequities in teaching practices (↟FAWE, 2019; ↟Crompton et al., 2021). Gender-responsive pedagogies are often used to examine the extent to which the learning materials, methodologies, content, learning activities, language use, classroom interaction, assessment and the set up of classrooms are suitable to respond inclusively to the diverse and intersectional needs of boys and girls in the teaching-learning process (↟UNESCO, 2017). In practical terms, this approach invites and support teachers (and potentially other stakeholders too) in exploring and identifying the specific and individual needs of different groups of children - and intends to lead to the implementation of solutions targeted at improving the levels of inclusivity, impact and equity of different pedagogical aspects of a teaching intervention (↟FAWE, 2019).

The RTP presents insights related to practical experiences in adopting gender-responsive pedagogies and holistic approaches to improve the pedagogical functions of an EdTech intervention. As illustrated in ↟Gutierrez Bernal et al., (2021); "*To improve the quality of the RTP, the TSC held a refresher course for teachers who were delivering the RTP lessons. This training included a Life-Skills Programme specifically designed to decrease the negative effects of the pandemic over girls' education. (…) It included training in lesson delivery, script performance and gendered education*." (p.2). This training was organised in partnership with multiple development agencies, such as Plan International, World Vision, United Nations Populations Fund (UNFPA), Save the Children and a government gender-education specialist. The training was organised together with a campaign inviting different stakeholders, and especially men, to support school-age girls in listening to the RTP programme (↟Gutierrez Bernal et al., 2021).

Ezekiel Nonie, the TSC's Teacher Performance Manager, explained that considering gender-responsive pedagogies during inception led to the facilitation of professional development support for teachers and to the implementation of approaches aimed at improving the quality and equity of the intervention. The training for professional development was based on facilitating opportunities for teachers to further improve their subject knowledge, discuss the topics of inclusion and access, develop their abilities to apply relevant pedagogies to the design of the radio sessions and implement ideas to enhance girls' education. Teachers were also invited to contribute to the training by sharing their existing knowledge, discussing concerns and exploring potential solutions collaboratively. Ezekiel Nonie mentioned that a key component of this training was also to present the objectives and anticipated challenges of the intervention directly to the teachers, which led to participatory discussions about how to improve children's learning outcomes inclusively by building on teachers' experiences, holistic approaches to increase participation and gender-responsive pedagogies. A key rationale for considering gender-responsive pedagogies was also to explore how the RTP could be improved from its implementation during Ebola and iteratively, for example by exploring how to enhance children's interaction during the radio sessions, increase girls' participation and improve the educational content delivered through the intervention.

Ezekiel Nonie also discussed ideas that could be seen as opportunities and challenges to adopt gender-responsive pedagogies in Sierra Leone, and in other LMICs. One of them was related to the potential of engaging with various

stakeholders to improve the uptake and pedagogical aspects of an EdTech intervention. For this intervention caregivers, adolescents, education experts and girls were directly invited to provide feedback and ideas to increase the participation of girls and to improve educational content, learning activities and language use of the radio sessions. Ezekiel Nonie also mentioned that implementing the RTP shed light on the importance of considering ongoing and continuous opportunities aiming at supporting teachers to design, implement and improve an EdTech intervention. For the RTP, teachers were invited to join a WhatsApp[5] group where they could discuss challenges, ideas and opportunities to improve the radio sessions - and most of the challenges discussed were based on exploring how to make the radio sessions more interactive and inclusive to girls and marginalised children. Another key lessons learnt emerging from facilitating TPD opportunities and using gender-responsive pedagogies for the RTP was related to the importance of recognising that teachers are a diverse group that have different concerns, needs and levels of confidence in terms of using technology and inclusive teaching practices, and that assessing these individual factors could be used to improve the impact of TPD and EdTech interventions. Ezekiel Nonie also mentioned that implementing the RTP illustrated the potential of considering complementary educational content on gender equality as part of EdTech intervention to improve girls' education in Sierra Leone, which in the case of the RTP included learning activities for children to learn about reproductive health, barriers in STEM, and gender-based stereotypes.

4.3. Tanzania: CAMFED and Worldreader

The Tanzanian government implemented a fee-free basic education policy in 2016, which led to a reduction of out-of-school children and higher retention rates in schools (↑Groeneveld & Taddese, 2020). This policy is based on making pre-primary and primary education free as well as waiving the registration and exam fees that caregivers had to cover for their children (↑Shukia & Shukia, 2020). Several government agencies are responsible for different educational policies, programmes and plans in Tanzania, and often consider how to use technology to improve children's learning outcomes and strengthen the education system (↑Groeneveld & Taddese, 2020). For example, the Tanzania Institute of Education (TIE) is in charge of designing the national curriculum and ensuring the quality of education in Tanzania. During the Covid-19 pandemic, the TIE launched a virtual library and broadcasted educational content through radio and television to thousand of children in Tanzania (↑Feruzi & Li, 2020).

Tanzania is in the top four countries in Africa in terms of the numbers of EdTech startups and companies (Crawfurd, 2020; Jordan et al., 2021). As presented in Section 3.3., this is aligned with current data showing that the mobile market in Tanzania has expanded significantly in recent years, with the number of personal mobile phones significantly increasing in recent years.

With support from the Girls' Education Challenge (GEC) programme, CAMFED (Campaign for Female Education) is a pan-African, grassroots led movement tackling poverty, inequality and injustice through girls' education and

[5] WhatsApp is a mobile-phone online application that enables users to send messages and make calls via the application for free.

women's leadership. With support from the Girls' Education Challenge, CAMFED targeted a range of structural and cultural barriers faced by girls attending secondary education in Tanzania and Zambia (↥Sabates et al., 2018). As further explained by ↥Jordan et al. (2021), CAMFED does not exclusively focus on using EdTech to achieve such objectives, but has included multiple interventions using technology to improve children's access to education. One of them was implemented between 2015 and 2017 and emerged from a partnership between CAMFED and Worldreader. Worldreader is a nonprofit organisation that provides children, teachers and caregivers in LMICs with free access to a library of digital books and literacy resources available via tablets and mobile phones. This intervention intended to use EdTech to improve the learning outcomes of children, and particularly girls, attending rural government schools and support their transition to secondary school. In total 1,300 Worldreader tablets with digital books (i.e. also called e-readers) were given to 75 schools in Tanzania (25 in Iringa, 26 Incoast and 24 in Tanga), which were based on inviting girls and boys to read stories in different languages and access literacy-related resources and learning exercises. Alongside access to digital books, the most marginalised girls in schools also received financial and psychosocial support, an approach that is aligned with CAMFED's holistic approach to designing and implementing educational interventions (↥Stanfield et al., 2018).

This intervention was evaluated with a study involving students (n=216) and teachers (n=12) and illustrated overall promising results (↥Stanfield et al., 2018). The majority of the students, for example, reported improved learning outcomes in pronunciation and literacy, in both Swahili and English. A significant improvement in school attendance due to the use of the Worldreader tablets in the classroom was also found. The three most prominent challenges that emerged from this study were related to a shortage of tablets, difficulties to access electricity to recharge the tablets and teachers expressing needing additional support to further learn how to efficiently use tablets in classrooms.

The Worldreader and CAMFED intervention was designed with intentions to reach, impact and provide educational opportunities to marginalised girls in Tanzania. Some of the main objectives of this intervention was to improve girls' literacy and to ensure that more girls gain access to sustained education in Tanzania. To achieve this, two design considerations were considered important - namely, the use of holistic approaches as well as considerations of digital literacy capacity-building.

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4.3.1. Holistic approaches

There are different forms and levels of marginalisation within contexts - as a result of this, an important step in the design of an EdTech intervention is to understand the characteristics of marginalisation and inequalities in a given context (↑Unwin et al., 2020). Applying and contextualising holistic approaches can be used to design EdTech interventions that consider the complex and interconnected realities of reaching and impacting marginalised learners, and can ultimately lead to improving children's learning outcomes (↑Zubairi et al., 2021). Holistic approaches in the EdTech context would mean different ministries (e.g., Ministry of ICT, Ministry of Education), sectors (e.g., health, education) and funders (e.g., public, private) working together to ensure a joined up approach. To apply such approaches into practice, multiple avenues have been explored, some of them are presented below:

- Integrating context analysis as part of EdTech interventions - these analysis often refers to baseline studies that involve collecting data related to system-level dimensions of equity, marginalisation and gender inequalities in a given context (↑Samuels et al., 2022).
- Disaggregating data of different population groups and individuals by characteristics relating to inequalities and marginalisation - this is often presented as a key approach to increasing the efficacy and equity of EdTech interventions (↑Zubairi et al., 2021).
- Engaging with a wide range of stakeholders as part of EdTech interventions - these include stakeholders who sit outside of formal education systems (↑Rose et al., 2020; ↑Wodon, 2016). This is based on recognising that children facing severe inequalities or marginalisation are likely to be in out-of-school, in non-formal or informal education settings (↑Zubairi et al., 2021).
- Considering additional resources to implement EdTech interventions - these resources, both human and financial, are needed to implement plans to involve and impact marginalised learners. These resources are often used to remove financial barriers that marginalised children face in being able to access and participate in EdTech intervention (↑Zubairi et al., 2021; ↑Greenhill, 2017; ↑Rose et al., 2020; ↑UNESCO & UNESCO, 2017; ↑Wodon, 2016).

CAMFED's work with Worldreader in Tanzania presents a case study of an intervention applying a holistic approach to designing an EdTech intervention by considering multiple system-level dimensions of equity and gender inequalities. This approach considers historical, structural and economical barriers influenced by systemic and interconnected factors such as poverty, discrimination, violence, gender norms, early marriage and teenage pregnancy. CAMFED and Worldreader have used such an approach to design this initiative in Tanzania, and have

also actively provided financial and psychosocial resources to enable marginalised girls to have access to EdTech. They also engaged with stakeholders across sector silos and at different levels within the education system (Davies et al., 2016).

Nasikiwa Duke, the programmes director in Tanzania and Cathy Taylor, the director of development operations at Camfed, mentioned multiple experiences and ideas that have influenced the decision to apply a holistic approach to design this EdTech intervention. Community engagement and the inclusion of local stakeholders were described as crucial to ensure that the intervention was aligned with diverse local realities, opportunities and needs - and to increase and sustain its uptake over time (as of mid-2022, the Worldreader tablets are still being used in the schools where this intervention was facilitated). To implement this approach in practice, the team developed the idea of working with 'Learner Guides'[6] - also known as trusted mentors - who are locally-based young women who were invited to return to their former schools to support the implementation of this intervention, and to engage directly with girls, teachers, caregivers and local authorities to build on their ideas and needs to iteratively improve its impact. This idea was based on building a model where local and trusted young women could contribute to the sustainability, impact and contextualisation of the EdTech intervention. A range of incentives for participation were provided to the young women , such as opportunities to access loans for business ideas, to acquire certifications for professional development, to engage within a peer-support network and to build on their shared values of philanthropy and ambitions to improve girls' education. This intervention also considered the use of financial and psychosocial support to enable marginalised girls to access school and benefit from this intervention. The rationale of this was based on recognising that certain children would not be able to access this intervention if they were not provided such support. This was concretely done by inviting girls, identified by school and community based committees as highly vulnerable, to discuss their needs with Learner Guides and teachers - with CAMFED providing support provided to respond to those specific needs, such as accommodation if they lived far, uniforms, sanitary ware, clothes if they felt cold at boarding facilities (and/or blankets), distribution of nutritious food if they frequently felt hungry, etc. To provide psychosocial support, the team worked directly with specially trained teachers, local authorities and school administrators, and supported the Learner Guides to engage directly with girls and caregivers (including through regular home visits) to better understand what type of support would be needed and adequate.

Nasikiwa Duke and Cathy Taylor also discussed ideas that could be seen as opportunities and challenges to implement a holistic approach to EdTech design in Tanzania, and in other LMICs. They mentioned that in the regions where this intervention was implemented, children had access to a very limited number of books. Communicating that the Worldreader tablets could enable children and teachers to access large numbers of books as a key objective of this intervention was used to motivate and engage with local stakeholders, such as local authorities, teachers and caregivers. To ensure sustainability, Nasikiwa and Cathy also mentioned that it was important not only to work

[6] More information about Camfed's 'learner guides' can be found here

directly with local actors, but also to find ways to ensure that their work is recognised, and that their contributions are documented as factors that have contributed to the improvement of girls' education. They also mentioned that during the intervention the importance of exploring the potential relevance and contextualising the content of the books became very important - this was done by analysing how books were used by girls and by adjusting their content to local needs, preferences and interests. Lastly, this intervention also applied holistic and participatory approaches to creating feedback loops through the collection, analysis and use of data. The team supported local actors to collect data about the design and impact of the intervention and encouraged them to discuss findings and ideas for improvements directly with communities.

Worldreader participated in another study that provides additional design considerations for the development of inclusive and holistic EdTech interventions (↑R4D & Worldreader, 2017). The study was conducted in 2016 and presented findings related to barriers that girls and women face in accessing and benefiting from EdTech opportunities in Kenya, and more particularly to use mobile phones to read books. The findings pointed to the importance of considering economical barriers and inequities, that can be identified in potential disparities related to covering the costs of mobile-phone data for girls and boys, as well as in their time available to access an EdTech tool at home. Another finding referred to exploring gender roles and divergent perceptions related to the value of education for boys and girls. This study evidenced the relevance of considering social narratives that might hamper women, men and youth to perceive and understand the importance and benefits of education for all children. Lastly, the study also illustrated the suitability of evaluating the content of EdTech tools and books through an equity lens. The findings specifically illustrated that identifying educational content (e.g. digital books) that women and girls can relate to and that challenge negative gender social norms and stereotypes was considered relevant to encourage girls and boys to read and to attend school (↑R4D & Worldreader, 2017).

4.3.2. Digital literacy capacity building

Despite many scholars and practitioners still trying to reach a consensus on a definition of digital literacy, this term broadly refers to abilities and knowledge to use electronic tools (↑Martin & Grudziecki, 2006; ↑Lankshear & Knobel, 2008; ↑Osterman, 2012; ↑Peng & Yu, 2022). In addition to digital literacy being an essential precondition for digital learning, research has also shown that higher levels of digital literacy can lead children to reach improved levels of motivation, engagement and learning outcomes when participating in EdTech interventions (↑Kahu, 2013; ↑Ilgaz & Gülbahar, 2015; ↑Wei & Chou, 2020; ↑Kara, 2022; ↑Peng & Yu, 2022). Enabling teachers to use and feel comfortable with digital tools is also a prerequisite for using EdTech in classrooms (↑Hennessy et al., 2021; ↑Widodo & Riandi, 2013). Understanding how to effectively design and integrate capacity-building opportunities to enable children and teachers to acquire digital literacy skills as part of EdTech interventions in LMICs is currently an underexplored area of research, and especially when considering potential intersectional and gender disparities.

The evaluative study of the Camfed and Worldreader intervention in Tanzania illustrated a key finding related to digital literacy. The study evidenced the complexity and importance of measuring and improving teachers' digital

literacy in order to practically and sustainably use technology in classrooms (↑Stanfield et al., 2018). Evaluating levels of digital literacy could be used to design capacity-building opportunities targeted at enabling teachers, and other users, to feel comfortable in using an EdTech device, which could in turn support their inclusive and sustainable use. This is particularly important from an equity perspective, as gender gaps in digital literacy are often observed in LMICs (see Section 2).

Joan Mwachi, the regional director of East Africa at Worldreader, discussed the main reasons why digital literacy capacity-building was considered as part of the design of this EdTech intervention. The main reason was related to ensuring that the intervention was designed considering local needs for technology-based supply, infrastructure and support. Worldreader and Camfed supplied devices with digital literacy support to enable teachers and students to effectively and sustainably use the devices and the Worldreader content in practice. This support was also targeted at raising awareness of inclusive practices related to using technology and digital content in classrooms - for example by inviting teachers to reflect upon, and consequently tackle, potential gender disparities that were often observed when children were given access to technology in this context. The rationale of enhancing digital literacy capacity-building opportunities in classrooms was also based on intentions to reduce gender gaps in digital literacy at a community and home-based levels (and aligning the design of the intervention with the gender gaps in digital literacy observed in the Tanzanian regions where this intervention was implemented). Joan Mwachi explained that during inception, the team noticed that caregivers and community leaders tended to pay significant importance and efforts to amplifying and replicating practices promoted by local schools - this led to the decision to capitalise and build on this opportunity to drive change at a bigger scale by encouraging discussions on digital literacy between schools, homes and communities.

Joan Mwachi also discussed ideas that could be seen as opportunities and challenges to implement digital literacy capacity-building training in Tanzania, and in other LMICs. During inception, a scoping and mapping exercise was conducted, which included exploring levels of digital literacy in schools, homes and communities. This exercise was conducted by assessing how technology was accessed, used and perceived in different contexts and by diverse stakeholders - and it also disaggregated inputs by gender and other forms of marginalisation. Key elements that emerged from this exercise, and that were directly used for the implementation of this intervention, included the need to consider local perceived levels of complexity and confidence in using technology, and how gender could play an important role in influencing these. This was used to support the design of digital literacy capacity-building opportunities that started with digital literacy concepts that were considered easy to understand by diverse stakeholders in order to gradually increase their confidence and skills in using technologies. To improve the engagement and motivation of local stakeholders in participating in digital literacy capacity-building activities, Joan Mwachi mentioned the opportunity to explore discussing how technology could be used in everyday lives, and to improve children's access to quality education directly with teachers and other stakeholders. Lastly, a key implementing challenge faced by Worldreader and Camfed was related to providing ongoing and on-demand support on digital literacy to teachers. This was done by creating a teachers' community of practice (where they

could share questions and provide mutual support on digital literacy through a WhatsApp group) and by providing periodical support related to technology maintenance, but it could have included, as mentioned by teachers, individual continuous support for technical assistance and troubleshooting.

5. Framework

Our framework summarises and presents an overview of the literature, household data and practice-based indications presented in this background paper. **The main objective of the framework is to present evidence-based factors, introduced as barriers and enablers, that need to be considered to design EdTech interventions aiming at improving girls' education in LMICs, through an equity and intersectional perspective.** When reading and/or using this framework a few clarifications need to be taken into account:

I. The framework is based on recognising that to improve girls' education through EdTech, the access, use and content of EdTech interventions need to be analysed by considering evidence of existing barriers and enablers related to gender and EdTech. The barriers and enablers are broader than the educational technology in question in itself, because any EdTech intervention sits at the confluence of a range of other design decisions and factors - such as cultural, social and pedagogical - which may bring gendered effects in turn, so need to be considered in combination.

II. The framework presents evidence-based barriers and enablers related to the access, use and content of EdTech interventions that need to be considered to capitalise on the potential of Edtech to enhance girls' education (see columns titled Access, Use and Content). Considering these barriers and enablers could be used to improve the equity of Edtech design, and could ultimately lead to improve children's learning outcomes in equitable and inclusive ways. However, it is also important to note that the extent and quality of prior research on different barriers and enablers varies - and these are a starting point to then be considered in a given context.

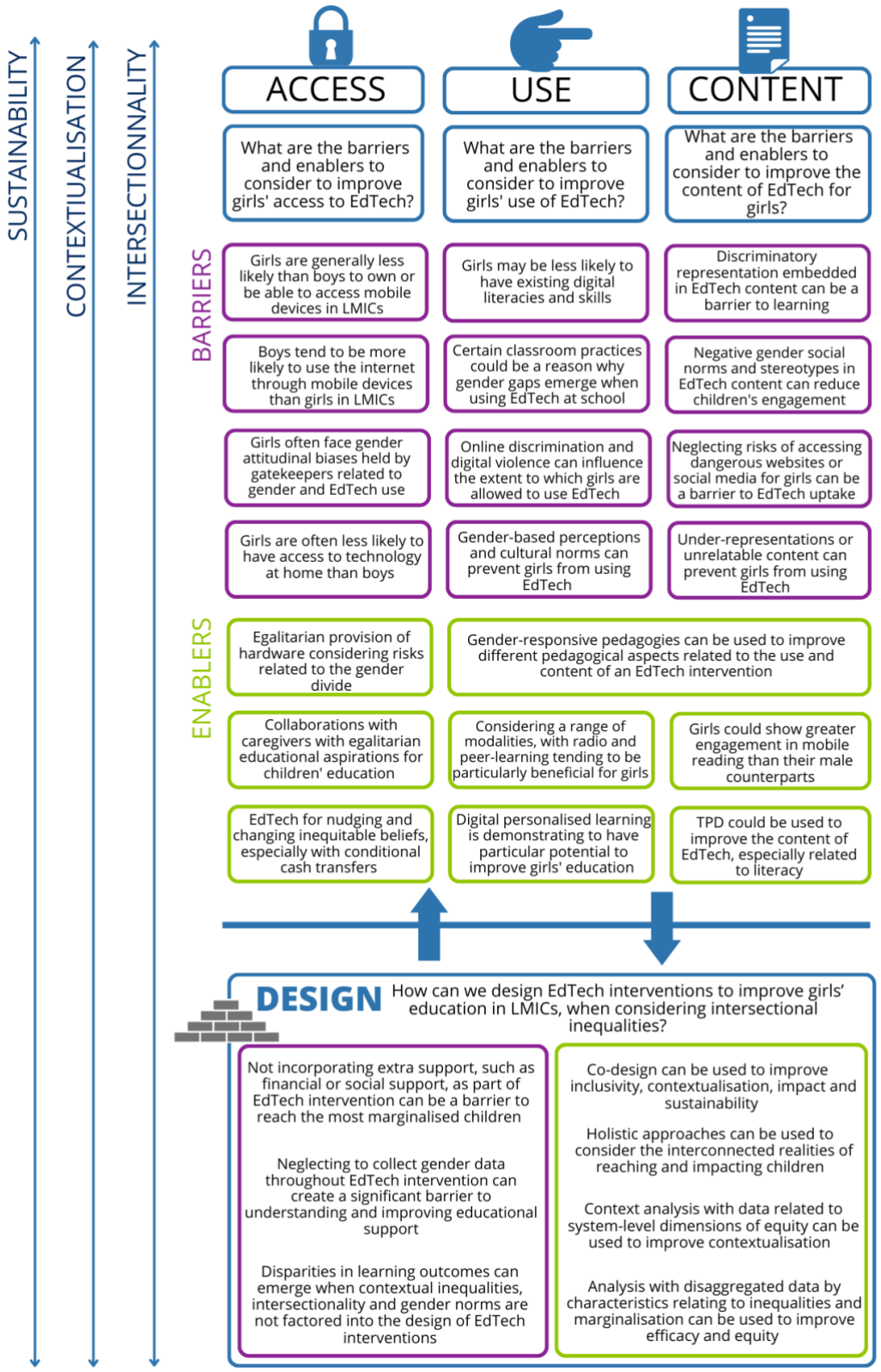
III. The framework also presents barriers and enablers that could be used to improve the overall design of EdTech inventions. These should be read as factors that could simultaneously improve the access, use and content of EdTech interventions (see box titled Design).

IV. This framework strongly supports that to create impact by applying any of these factors into practice, significant efforts need to be implemented to ensure that:

- The design of an EdTech intervention considers how to create sustainable impact over time, including by exploring how to impact policy-making processes (see arrows titled sustainability);
- The factors presented are re-analysed, questioned and adapted through local contextualisation (see arrows titled contextualisation);

- An intersectional lens is adopted to evaluate potential gender inequalities and the suitability of the presented factors in a given context by exploring how gender intersects with other socioeconomic indications, such as poverty, location, disability, ethnicity, language, migration, displacement, incarceration, religion, sexual orientation, and gender identity and expression in specific regions (see arrow titled intersectionality).

Figure 6. Framework to support girls' education with and through EdTech.



6. Recommendations and conclusion

Previous crises, such as wars, natural disasters and pandemics, have tended to disproportionately affect girls' education (↑GCPEA, 2014; ↑Sperling et al., 2016; ↑Nicolai et al., 2015; ↑Hallgarten, 2020). The Covid-19 pandemic prompted global school closures, and led to immediate responses relying on the use of EdTech to provide education continuity and to prevent girls' from falling behind in school. EdTech is proving to have promising potential to support girls' education in LMICs, and to ensure inclusive and equitable quality education for all. To further materialise this potential into sustained and inclusive educational improvements, evidence of factors that influence impact and equity need to be better understood. This could be used to illustrate what needs to be considered - including barriers that would need to be overcome and enablers that could be utilised - to design EdTech interventions that lead to improved and egalitarian learning outcomes for girls in LMICs. Considering, elevating and analysing the factors which create barriers and enablers in a given context could be used as a key approach to design impactful EdTech interventions.

This paper has introduced key barriers and enablers that need to be considered to design EdTech interventions to support girls' education through EdTech. These are barriers related to reaching the most marginalised girls, for example by not including special measures that consider marginalisation (e.g financial, health or social support) as part of EdTech interventions; neglecting to collect gender data throughout EdTech intervention to understand how to improve educational support; and, downplaying or ignoring the role of contextual inequalities, intersectionality and gender norms in supporting egalitarian learning through EdTech. In the design of EdTech interventions targeting girls, these socio-cultural and attitudinal norms need to be incorporated into the design of interventions, which often led to needs to work directly with households, local stakeholders and community actors. The enablers that have shown significant potential to support girls' education through EdTech include the use of co-design practices to improve inclusivity, contextualisation, impact and sustainability; the application of holistic approaches to consider the interconnected realities of reaching and impacting children (for example by engaging with diverse stakeholders); the inclusion of context analysis with data related to gender and system-level dimensions of equity to improve contextualisation; and, the disaggregation of data by characteristics relating to inequalities and marginalisation to improve the efficacy and equity of EdTech interventions.

This background paper has also presented the importance of studying and considering gender-based barriers that can emerge specifically in the access, use and content of EdTech interventions. It has illustrated that barriers to inclusive EdTech access tend to include gender disparities related to digital technology ownership, internet access, usage of technology at home and attitudinal biases held by gatekeepers. It has also evidenced that barriers to inclusive EdTech use include gender inequalities that can be found in levels of digital literacy and skills, classroom practices when EdTech is used in schools, online discrimination and digital violence - as well as gender-based perceptions and cultural norms that directly influence the equitable use of technologies for learning. In relation to EdTech content, we found that gender disparities can appear from content that captures discriminatory

representations, negative social norms, stereotypes, under-representations, unrelatable content for girls as well as content that guide children to accessing websites that are particularly dangerous for girls.

We have also collected evidence-based and practice-based factors that could be used as enablers to design EdTech interventions that lead to improvements for girls' education. To improve gender equality in EdTech access, promising enablers include the provision of hardware by considering risks related to the gender divide, collaborations with caregivers with egalitarian educational aspirations for children' education and the use of EdTech for nudging and changing inequitable beliefs, especially when used with conditional cash transfers. Enablers to improve egalitarian use of EdTech include the application of gender-responsive pedagogies, consideration for including different types of modalities as part of EdTech interventions (with radio and peer-learning tending to be particularly beneficial for girls) and the use of digital personalised learning, especially when developed using local data to build and train AI algorithms. Lastly, to improve the inclusivity of EdTech content, the application of gender-responsive pedagogies, the use of mobile reading, and the facilitation of TPD opportunities are showing to be particularly promising for supporting girls' education through EdTech.

The educational and socioeconomic consequences of the Covid-19 pandemic are likely to exacerbate existing gender disparities unless interventions are implemented to address the learning needs of all. The educational repercussions of the Covid-19 pandemic are unlikely to be solved exclusively through school reopening, and EdTech could be continued to be used as a remedial, targeted and/or complementary approach to improve education. To realise this, and achieve quality and inclusive education for all, educational interventions should be designed by considering the evidence and potential of EdTech to improve girls' education in LMICs as well as tackling gender disparities in and through EdTech.

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