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Country-Level Research Review: EdTech in Tanzania

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Contents

Abbreviations and acronyms

CESP	Covid-19 Education Response Support Programme
CoICT	College of Information and Communication Technologies
CPD	Continual professional development
CSE	Computer Science and Engineering
CSSC	Christian Social Services Commission of Tanzania
CVL	Center for Virtual Learning
DIT	Dar es Salaam Institute of Technology
DLI	Disbursement linked indicator
DUCE	Dar es Salaam University College of Education
EdTech	Educational technology
EGMA	Early grade mathematics assessment
EGRA	Early grade reading assessment
EMIS	Education management information system
EPforR	Education Programme for Results
ERIC	Education Resources Information Center
ESDP	Education Sector Development Plan
ESSA	Education in Sub-Saharan Africa database
GATE	Gender Awareness and Transformation through Education project
GPE	Global Partnership for Education
HDIF	Human Development Innovation Fund
HE	Higher education
ICT	Information and communication technology
ICT4D	ICT for development
INSET	In-service education and training
IT	Information technology
IYF	International Youth Foundation
KOICA	Korea International Cooperation Agency
LAYS	Learning Adjusted Years of Schooling
LMIC	Low- and middle-income countries
MoEST	Ministry of Education, Science and Technology
MoEVT	Ministry of Education and Vocational Training
MOOC	Massive open online course

NECTA	National Examinations of Tanzania
OER	Open educational resources
OLPC	One laptop per child
OOSC	Out of school children
OTEAS	Online teachers employment application system
PEA	Political Economy Analysis
PO-RALG	President's Office - Regional Administration and Local Government
PSLE	Primary school leaving examination
RLI	Research landscape index
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Educational Quality
SEKOMU	Sebastian Kolowa Memorial University
SEND	Special educational needs and/or disabilities
SIDA	Swedish International Development Cooperation Agency
SIS	School information system
SMS	Short messaging service
TEA	Tanzania Education Authority
TESSA	Teacher Education in Sub-Saharan Africa programme
TIE	Tanzania Institute of Education
TPACK	Technological pedagogical content knowledge
TPD	Teacher professional development
TSC	Teachers' service commission
TVET	Technical and vocational education and training
UDSM eLRG	University of Dar es Salaam eLearning Research Group
UNDP	United Nations Development Program

Executive summary

This document presents a review of the research landscape in Tanzania in relation to EdTech research focused at the level of school-based education, excluding higher education (HE). The review draws upon the research literature, policy documents, grey literature, and interviews with key stakeholders in order to present an overview of the research landscape in Tanzania. There is a substantial body of relevant EdTech research that has been undertaken in Tanzania in the past decade. Eighty research articles were identified for inclusion in the review. This document provides an overview of trends in this literature and key actors and projects. Furthermore, existing research related to EdTech in Tanzania is discussed in relation to five key focus areas of the EdTech Hub's future research. In combination with political economy analysis, three areas for future research that would be practical and likely to have high impact are identified and described.

1. Introduction

This review provides an overview of EdTech research in and about Tanzania in order to understand the opportunities for carrying out further research in the country, and how EdTech Hub can collaborate with researchers, practitioners, and policy-makers most effectively. The report will be important for researchers on EdTech in Tanzania and the surrounding region, as well as for EdTech implementers seeking to understand what evidence exists and what is needed. Through analysis of existing literature, interviews with key stakeholders and analysis of the broader political economy, the gaps in evidence that have the highest potential for impact on education are identified for future research priorities of EdTech Hub. These priorities can also serve more broadly to foster and sustain conversation with a community of practice and learning among education stakeholders about the use of EdTech in Tanzania.

1.1. Structure

The review is made up of seven sections:

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

1.2. Methodology

As the review had several aims, a combination of approaches was used in order to draw upon a range of sources. This included statistics and policy documents, the existing body of published research literature, and interviews with some key stakeholders.

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

(↑Groeneveld & Taddese, 2020). Furthermore, interviews with eight key stakeholders were included in the political economy analysis.

A review of the existing published academic research literature was also undertaken to provide an overview of the existing research landscape around EdTech and education for school-aged learners in Tanzania (Section 3), and identify existing studies — or gaps in the existing literature — in relation to five key focus areas relevant to the EdTech Hub's future research (Section 5). The literature review also provided a way of exploring the academic stakeholders involved in EdTech in Tanzania (Section 4). Tanzania has been a focal point for EdTech research in recent years, and as a result, 80 academic publications were identified for inclusion in the review. The search process and its limitations are described in further detail in Section 3.

Through the combination of research approaches, a set of priorities was identified and mapped to five topic areas that will be the focus of EdTech Hub's research. The focus on evidence gaps within five key focus areas (Section 5) allows the Hub to diversify its research priorities appropriately within Tanzania, in response to the priorities of research, practice, and policy. Situating the priority research areas within the political economy analysis (Section 6) brings a practical dimension. Brought together, the examples for specific research collaborations (Section 7) that match the most significant evidence gaps propose a potential future direction for high-impact research in Tanzania that is aligned with both the priorities within the country and those identified by the Hub.

2. Summary of the EdTech operating context

This section contextualises the EdTech space in Tanzania. It is supported by Annex A, which presents selected data points to help illustrate the state of EdTech in Tanzania within the broader national context. This section outlines the structures, policies and programmes, and recent developments which underpin Tanzania's education system.

2.1. Systems: policy, structure, and provision

The latest Education Sector Development Plan (ESDP) developed by the ↑Ministry of Education, Science and Technology (2018) covers the 5-year period from 2016/2017 to 2020/2021. The core policy initiatives underlined within the latest ESDP, are:

1. A commitment to providing 12 years of free and compulsory basic education to the entire population;
2. The progressive expansion of Technical and Vocational Education and Training (TVET) to upskill the workforce, which will support the ambition to become a middle-income country by 2025.[1]

Since the introduction of the fee-free basic education policy in 2016, school enrolment has increased, the number of out of school children (OOSC) has decreased, and the likelihood of completing schooling has increased. However, the ESDP notes the challenge in simultaneously increasing school access and improving learning outcomes (↑Global Partnership for Education, 2021), though learning gains in core subjects (English, mathematics and Swahili) have been seen in primary schools in recent years (↑Trako, et al., 2019).

The ↑Ministry of Works, Transport and Communication's (2016) Implementation Strategy for the National Information and Communication Technology Policy identifies several barriers to information and communication technology (ICT), such as a scarcity of legal frameworks around data privacy and storage, and constraints regarding security and infrastructure. While set policy objectives offer ways in which these challenges can be addressed, the strategy lacks guidance on how to operationalise the objectives or measure when the desired outcomes have been achieved.

According to ↑Groeneveld & Taddese's (2020) EdTech Hub country scan of Tanzania, several government agencies are responsible for different areas

[1] See ↑Battaile's (2020) World Bank blog, which details Tanzania's recent shift from low- to lower-middle income status.

within the education space. The Tanzania Institute of Education (TIE) is responsible for content development and is likely to play a lead role in implementing an online and offline portal for teacher education and professional development given its mandate to ensure quality education with appropriately trained teachers (↑World Bank, 2019). The Teachers' Service Commission (TSC) is an autonomous regulatory authority with a range of responsibilities including teacher deployment, TPD, codes of conduct and disciplinary issues (↑Mfaume, et al., 2019). National Examinations of Tanzania (NECTA) manages assessment in basic education. While the Tanzania Education Authority (TEA) has a mandate to secure funds for education, including EdTech initiatives, several agencies under the Ministry of Education, Science and Technology (MoEST — previously Ministry of Education and Vocational Training; MoEVT) play a role in implementing these initiatives (↑Ministry of Education, Science and Technology, 2018). However, donors or private sector companies usually lead EdTech initiatives, rather than the government.[2]

Beyond government schools, private provision of education in Tanzania can take the form of community- or faith-based schools, and non-profit and for-profit schools. Historically, however, the initial socialist governments spearheaded by Julius Nyerere that led Tanzania following independence on 9 December 1961 followed a nationalisation agenda, where all private schools became state-owned public institutions. Under Nyerere's stewardship, Tanzania came close to achieving universal primary education with village-based education programmes structured around the notion of *ujamaa* (or collectivity) (↑Hardman, et al., 2011). By the 1980s, Nyerere faced growing pressure to relax this agenda, particularly from international organisations that offered crucial loans and aid to Tanzania. This pressure eventually led Nyerere to step down, and deregulation occurred in the education sector, enabling private provision of education again (↑Unterhalter, et al., 2020). The criteria for registering a private school in Tanzania relates to the safety and suitability of school buildings and other educational facilities and equipment; teacher qualifications and working conditions; and the gap that the proposed school will fill in educational services (↑ibid.). Article 23 of the 1978 National Education Act (amended 1995) itself stipulates: "no person shall establish a non-government school unless it is intended to provide education in accordance with the national education policy" (↑United Republic of Tanzania, 1995).

[2] See Table 8 of ↑Groeneveld & Taddese's (2020) recent EdTech Hub country scan report for further details of EdTech initiatives relevant to the Tanzanian context.

2.2. Teachers

In 2018, the pupil–teacher ratio stood at 51:1 at primary level and 21:1 at secondary level (↑World Bank, 2021). Note that these figures represent an average, and there is wide variation in teacher distribution, with some schools having ratios in excess of 200:1. A ↑World Bank (2017) report posits the critical need to build a competent and effective teaching workforce that can meet the future demands of the system. It quotes the ESDP estimate that the overall teaching workforce needs to double in the next decade in order to meet steady rises in student enrolment rates (↑ibid.).

Further challenges lie at the teacher level with regards to classroom instruction. ↑Hardman, et al. (2011) refer to an analysis of 300 lessons from eight districts (covering primary English, mathematics, Kiswahili and science at Standards 3 and 6) showing that pupil-centred forms of learning made up just 14% of lesson time with paired or group work making up only 6% of lesson time, whereas traditional 'chalk and talk' methods took up over half of the lesson time (↑ibid.). Teachers' disproportionate focus on 'chalk and talk' classroom instruction is also highlighted by ↑Chirwa (2018). There is a clear need for teacher education and professional development programmes to develop teachers' capacities in relation to making productive use of learning time, as can be seen when considering the literature in relation to effective learning (for example, ↑Schweisfurth, 2013; ↑Iyare, et al., 2018).

Though English language acquisition is considered important by teachers, the standard of instruction in English is low (↑UNICEF, 2017a). This means that, in practice, teachers often revert to Kiswahili in secondary classrooms despite English being the intended language of instruction (↑Groeneveld & Taddese, 2020). The debate around what the appropriate language of instruction is — whether Kiswahili or English — and at what levels, is hotly contested between Tanzanians in government, schools, and in the media, with local, national, and international pressures at odds (↑UNICEF, 2017a). This debate has added complexity when considering the further 120 languages spoken across the country (↑Rubagumya, 2007), meaning that there are populations who have proficiency in neither English nor Kiswahili. This is estimated by ↑Rubagumya (2007) (cited in ↑UNICEF, 2017a) to be around 15%. This 15% is heavily weighted towards rural, marginalised communities; thus, language policy that neglects these 120 'minority' languages serves to further marginalise these groups.

According to the figures listed in Annex A, there were 44,546 learners with special educational needs and/or disabilities (SEND) recorded in 2016. However, there remain constraints around the levels of support teachers can afford these students, with few qualified to address these specific needs (↑Groeneveld & Taddese, 2020). For example, ↑Muyungu (2015), estimates that

"90% of the teachers who are employed for both regular and inclusive schools are graduates with regular bachelor of education" (p.5) rather than graduates who have specialised in SEND.

2.3. Learners

In 2019, primary enrolment was 98.8%, compared to 32.0% at secondary level. ↑Groeneveld & Taddese (2020) state that at each educational level enrolment rates are approximately equal for boys and girls, with girls generally enjoying slightly higher rates. However, 2007 and 2015 Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ) data shows that there is an attainment gap between boys and girls in Tanzania (SACMEQ, cited in ↑Al-Samarrai & Tamagnan, 2019). Furthermore, gender parity in terms of enrolment disappears at the HE level, where male enrolment (5.2%) is almost double that of female enrolment (2.8%) (↑Ministry of Education, Science and Technology, 2018).

Annex A shows 3.8% of children currently attend private schools at primary level, rising to 16.9% of children at junior secondary level and 32.0% at senior secondary level. While the proportion of students enrolled in private primary schools is low, in the 2014 Primary School Leaving Examination (PSLE) ranking, the top 15 schools were all private schools, and of the top 50, only five were public schools (↑Suleiman, et al., 2015). At secondary level, of the top 50 secondary schools based on exam results, only one was a public, government-run school (ranked 35th; ↑ibid.). These rankings indicate improved learning outcomes for students schooled in the private system.

When viewing learning outcomes through an urban / rural lens, 2015 data gathered by UWEZO shows that children living in rural areas of Tanzania score on average 5% less than children living in the capital, Dar es Salaam (↑World Inequality Database on Education (WIDE), 2017).

Overall, this data indicates inequalities in learning between boys and girls, high-income and low-income students, and urban and rural students.

2.4. EdTech initiatives

EdTech initiatives are relatively widespread in Tanzania, with several projects and programmes implemented in the country having been evaluated and reported on in the research literature. We will explore this literature in more detail in Section 3 of this review. Here, we outline information around the number of EdTech initiatives in Tanzania and the 2014 XPRIZE competition, which provide some useful context to the EdTech research sector in Tanzania.

The EdTech Hub's tools database[3] includes 45 records that show Tanzania as a 'target country' for EdTech initiatives, while 12 records show up when searching for Tanzania as the 'home country' of EdTech initiatives (Annex B). According to this dataset, this places Tanzania in the top four African countries in terms of the number of EdTech companies (↑Crawfurd, 2020). Of the 12 Tanzania-based companies, Ubongo has reached the largest scale. Ubongo develops the educational cartoon programme *Ubongo Kids* for standard II to IV, which is broadcast via television. 14% of Tanzanian households have TVs, and over 13 million users per month (and 17 million total users) are estimated to engage with broadcasts of *Ubongo Kids*. In addition to television broadcasts, Ubongo uses a short messaging service (SMS)-based system to conduct assessment with registered users. ↑Watson, et al. (2020) explored the effectiveness of Ubongo Kids and found a significant relationship between children watching the cartoon and their mathematics capability, while also highlighting the cost-effectiveness of the EdTech initiative. This study reinforces findings from a study by ↑Borzekowski (2018), who looked at the effects of another cartoon made by Ubongo — *Akili and Me* — on children's learning and found a positive relationship between exposure to the television programme and school readiness.

Another example of EdTech's strong presence in Tanzania is the $15 million 2014 Global Learning XPRIZE which focused on open educational software to develop learners' literacy and numeracy skills. Five finalists received $1 million each to test their EdTech innovation with 3000 Tanzanian learners across 170 villages. The XPRIZE has formed a partnership with UNESCO and, through this partnership, has developed a relationship with the Government of Tanzania; thus the field tests are located in rural Tanzanian villages where learners do not generally have access to formal schooling (↑XPRIZE, 2018; ↑Woollaston, 2020). Some top-level results from this field test include learning gains in the following areas: children able to read a single word (increasing from 10% of participating learners to 45%); children able to solve at least one addition or subtraction mathematics problem (from 23% to 66%); and children able to write a simple word (from 26% to 67%) (↑XPRIZE, 2019). The five projects which took part in the field test were CCI, Chimple, Kitkit School, onebillion, and RoboTutor. Kitkit School and onebillion were ultimately jointly awarded the prize. The XPRIZE examples reflect a broader trend within Tanzania: while EdTech initiatives are abundant, they are typically not integrated into classrooms across the education system yet, as the government has tended to

[3] https://airtable.com/shrWkzpnLTpjP2ip8/tblUhRGOHZgazHHY5

prefer a traditional 'build first' approach[4]. Projects which have published their findings and related research will be discussed further in Section 3.

2.5. Covid-19 and reopening schools

Following the first confirmed case of Covid-19 in Tanzania, all schools closed in mid-March of 2020 (↑Feruzi & Li, 2020; ↑Groeneveld & Taddese, 2020). At this time, the TIE created a virtual library and started broadcasting educational content through radio and television (↑Feruzi & Li, 2020). National, private, and community TV and radio channels began broadcasting educational content in April 2020. Schools closures were relatively short, lasting only three months and reopening on 29th June (↑Todd, 2020a). To compensate for lost learning, MoEST extended the school year and cancelled holidays, so the negative impacts of Covid-19 upon education are expected to be lower than in neighbouring countries.

The government has drawn on Tanzania's relatively high mobile phone penetration to reach parents and guide them on child protection and home learning. Various partner organisations have supported MoEST to ensure remote learning is effective. For example, Children in Crossfire have expanded their pre-school education programme in Tanzania[5], while UNICEF has promoted parental engagement in home learning by developing guides for parents and caregivers on how to monitor learning (↑Conto, et al., 2020). As a further measure, NECTA adjusted national examination schedules to allow for flexibility when taking exams.

Significant funding to support the country's Covid-19 response has been provided by the Global Partnership of Education (GPE) through their grant agent, the Swedish International Development Cooperation Agency (Sida)[6]. The Covid-19 Education Response Support Programme (CESP) grant application is intended to support:

- Distance learning by providing educational content and lessons through multiple modalities, such as television, radio, SMS, and online platforms.
- SEND learners by developing Braille and large print materials for children with vision impairment, and sign language interpretation for children with hearing impairment.
- Teachers to enhance learning by providing guidance on distance platforms and airtime to reach students.

[4] See ↑Mtebe & Kondoro (2019), for example, discussing the Halostudy Learning Management System (LMS). The Halostudy LMS launched in 2017, to support secondary education.
[5] https://www.childrenincrossfire.org/we-are-partnering-with-paragon-health/
[6] https://www.globalpartnership.org/sites/default/files/document/file/2020%2009%20COVID-19%20AFF%20Request%20Tanazania%20Mainland%20-%20Verified.pdf

- The hardest-to-reach areas by distributing textbooks to schools and offering additional incentives for students to return to school while improving the student–textbook ratio.[7]
- Health and hygiene by installing hand-washing stations and providing water disinfectants in schools located in the areas worst affected by Covid-19 (↑Ministry of Education, Science and Technology, 2020).

A study by ↑Ngutuku (2020) collected essays from children and adolescents aged 10–18 on their perspectives of the effects of Covid-19 on their lives. The essays offered varied insights into the impact of the pandemic on these individuals. Notable insights related to school closures specifically spoke to the lack of a 'safe space' for girls in some instances, an increased burden of household chores, and the dismantling of collective ideals when community activities had to be put on hold.

In June 2020, the government announced that schools would be reopened, with the late President John Magufuli stating that the country was "free of Covid-19" (↑BBC, 2020). Schools remain fully open as of 1st February 2021.[8]

[7] For more information on student–textbook ratios, see Table 3.1 of the ↑Ministry of Education, Science and Technology's (2018) Educator Sector Performance Report 2017/2018.

[8] See UNESCO's Global Monitoring of school closures caused by Covid-19 here: https://en.unesco.org/covid19/educationresponse

3. The texture of the research landscape on EdTech

This section provides an overview of the existing research landscape in relation to EdTech in Tanzania. EdTech research has been and continues to be, actively undertaken in Tanzania (↑Mtebe & Raphael, 2018a). For example, Tanzania is one of the most prominent countries in the Education in Sub-Saharan Africa (ESSA) database of educational research publications[9]. Furthermore, analysis of the ESSA database shows that Tanzania sits within the top five countries in Sub-Saharan Africa which have produced scholarly outputs in collaboration with researchers based outside Sub-Saharan Africa (↑Asare, et al., 2020). Consequently, there is an existing body of EdTech research that EdTech Hub can build upon. The characteristics of this research will be summarised in this section. This analysis of the literature will also inform the discussion of authors and major projects in Section 4, and studies that align with EdTech Hubs' five priority areas for future research will be discussed in further detail in Section 6.

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

1. Initial searching of key EdTech research documents for Tanzania-focused studies. This included existing reviews of EdTech studies in LMICs (for example, ↑McEwan, 2015; ↑Mtebe & Raphael, 2018a; ↑Rodriguez-Segura, 2020), evidence reviews, and EdTech Hub publications;

2. Searching specialist education research databases (ESSA, ERIC[10]) for all Tanzania-focused studies and selecting those which met the inclusion criteria (published since 2010, being EdTech-related, and focused on school-aged learners, teachers, or aspects of the educational system relevant to school-aged learners);

3. Searching general academic databases (Scopus, Google Scholar) for 'Tanzania' *and* a range of general EdTech terms (such as educational technology, e-learning, technology-enhanced learning, mobile learning);

4. Follow-up searches for further articles from particular authors and projects which emerged from the results of the previous searches (including searching academic social networking sites).

[9] https://essa-africa.org/AERD
[10] https://eric.ed.gov/

While it is not possible to guarantee that the search results are exhaustive given the wide range of technologies and approaches that can be considered 'EdTech', continued searches did not produce novel results meeting the criteria. Thus, although this approach stops short of being a systematic review — which would be a substantial task to undertake — we are confident that the sample is an accurate representation of EdTech research literature focused on school-aged learners, teachers, or aspects of the educational system relevant to school-aged learners in Tanzania.

Articles identified through the search process were then read in full, and information about those which met the search criteria (a small number were excluded on reading the full document text) was entered into a spreadsheet mapping their characteristics to a pre-defined 'research landscape index' (RLI) framework. Eighty articles, written by 150 unique authors, were entered into the RLI. Categories within the RLI included: bibliographic information; authors; institutions; funders; research methods; sample size; study topic; and relevant Hub thematic area. The information is provided in full in Annex C.

Reflecting trends in other databases such as ESSA (above), the literature review revealed that EdTech research has been an active area for academic research in Tanzania. The 80 articles selected for inclusion in the review comprised 42 journal papers, 27 conference papers[11], five reports, five books or book chapters, and one master's thesis. A range of different research methods and approaches were used (Figure 1). Boxplots of sample sizes are shown in Figure 2. Sample sizes were recorded from 63 of the 80 papers (theoretical or literature-based articles were excluded, for example). The research literature includes some notably large-scale studies; note that Figure 2 does not include the four largest studies, which ranged from 1,137 to 38,682 participants.

[11] This is an underestimate of conference publications as it mainly consists of papers published in high-profile conferences organised by international societies such as the ACM and IEEE, which publish formal proceedings and are indexed by Scopus. Papers from smaller conferences are harder to consistently search and locate online.

Figure 1. *Frequency of research methods using the RLI typology in the articles included in the literature review.*

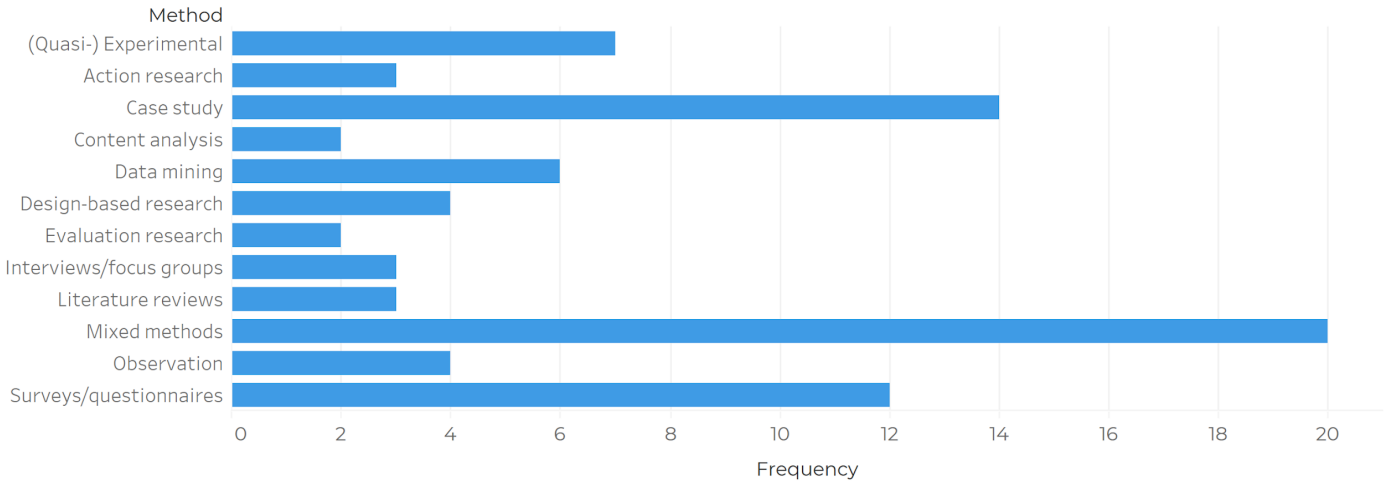
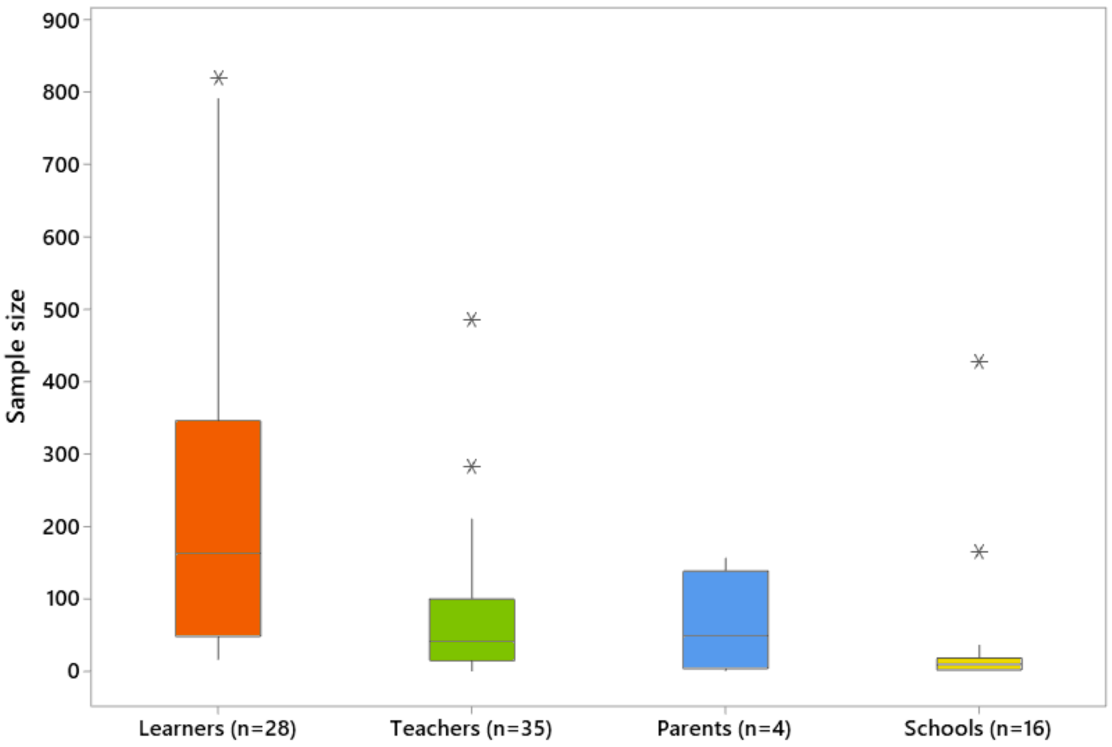


Figure 2. *Boxplots of sample sizes in the articles included in the literature review. Note that four papers, which used samples larger than 1,000, were not included in this chart.*



Authors and projects will be discussed in Section 4, and the topics of research (and how they align with EdTech Hub's five focus areas) will be discussed in Section 5.

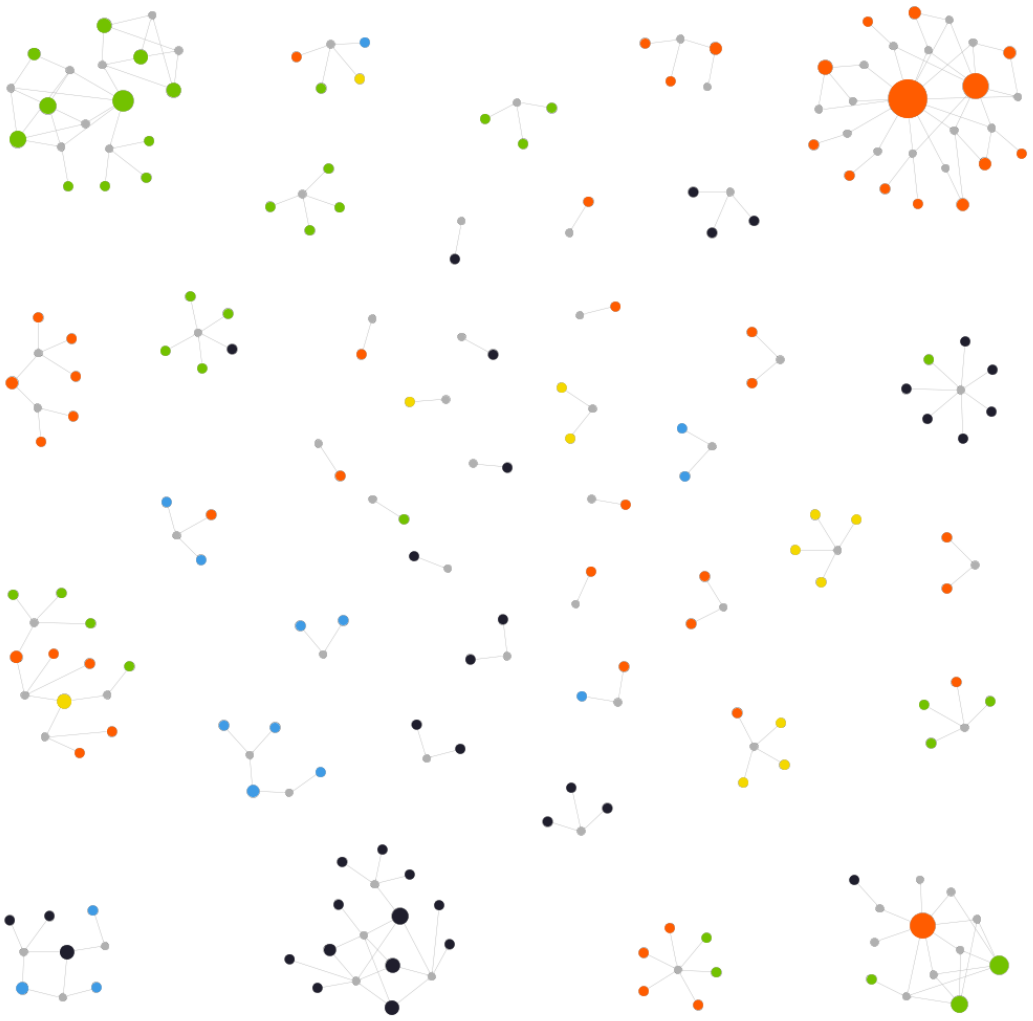
4. Key stakeholders within the research landscape on EdTech

This section provides an overview of some of the individuals and organisations with interests in relation to EdTech research in Tanzania. As most of this information is sourced from literature that has already been published, and primarily academic journals, the information in this section may not be exhaustive. For example, researchers who have not published in outlets that are indexed by the databases, or are working on EdTech projects which have not reached the publication stage yet, will not be included. Furthermore, the inclusion criteria for the literature review limited the search to EdTech in the context of school-aged learners, teachers, or aspects of the educational system relevant to school-aged learners; this would also exclude Tanzania-based academics with EdTech research interests in relation to HE, which has also been an active area for academic research (↑Mtebe & Raphael, 2018a).

The academic literature is subject to publication biases and although the research strategy was intended to be as inclusive as possible, this source is unlikely to include all the individuals working on EdTech in Tanzania. Nonetheless, the authorship of the articles included in the literature review is one way of exploring the academic research community with interests related to EdTech in the context of school-aged learners and teachers in Tanzania. Figure 3 depicts a co-authorship network of links between papers and their authors, within the reviewed academic literature.

Characteristics of the data visualisation in Figure 3 reveal insights into the academic community related to EdTech research in Tanzania. This section provides an overview of some of the key stakeholders that emerged primarily from the research literature review, with reference to the co-authorship network, arranged according to three sub-sections: first, academics based in Tanzania; second, major EdTech projects; and third, research organisations with interests related to EdTech research in Tanzania.

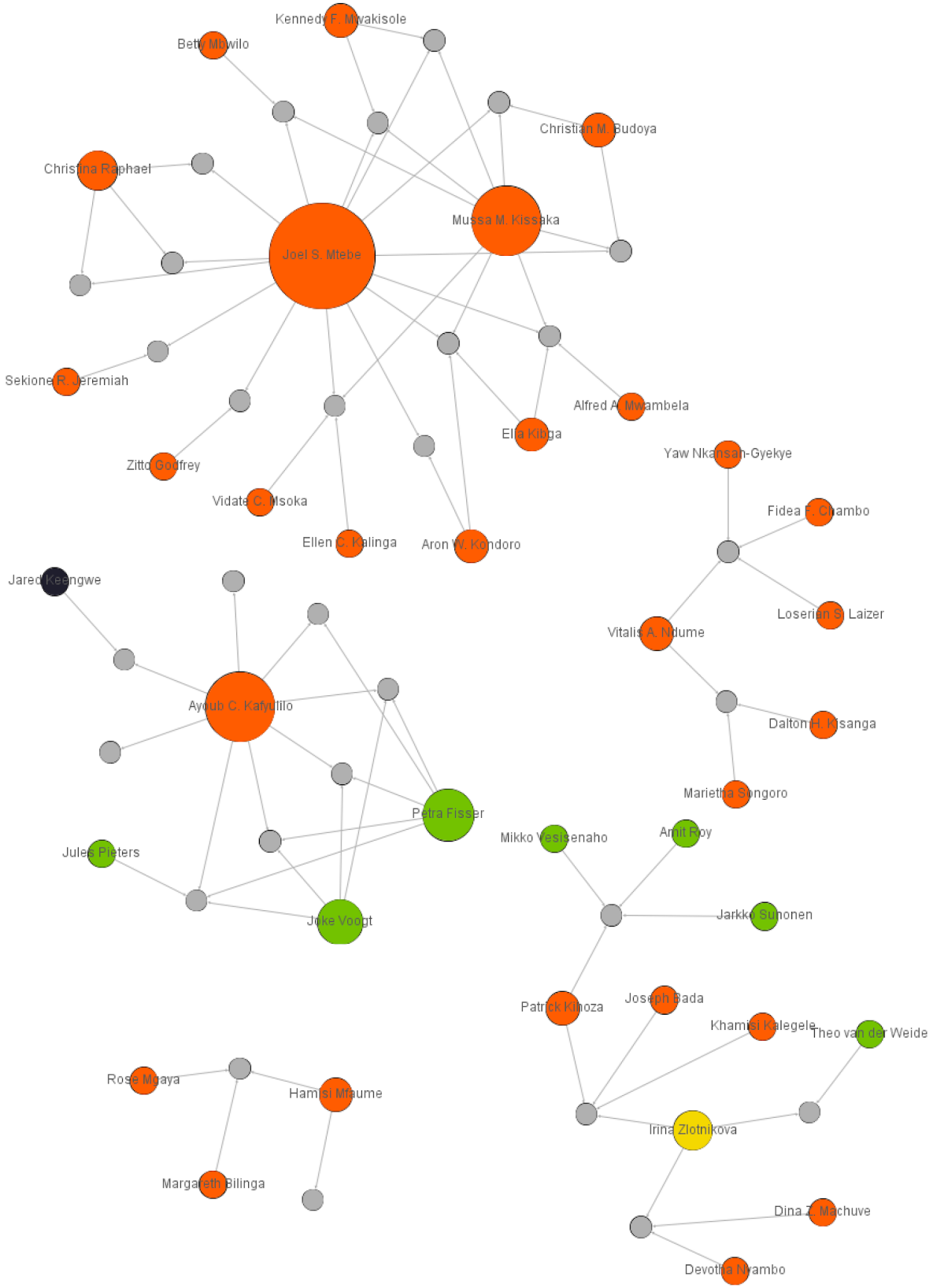
Figure 3. *Co-authorship network of the 80 papers included in the literature review. Links connect authors (coloured nodes) to articles (grey nodes). Node size is scaled according to the number of articles authored in the sample. Authors based in Tanzania (49) are shown in orange; in North America, dark blue (37); in Europe, green (37); in Asia, light blue (15); and in other African countries, yellow (12).*



4.1. Leading academics and independent researchers

The collection of research literature introduced in Section 3 included authors from across 12 HE institutions in Tanzania (shown as orange nodes in Figure 3, above). The full list of institutions is shown in Annex C. The University of Dar es Salaam is the most frequent affiliation (17 of the 49 Tanzania-based authors), and the large cluster in the top right corner of Figure 3 are affiliated with this institution. This cluster is shown in detail in Figure 4.

Figure 4. *Clusters within the co-authorship network which include multiple papers (grey nodes), and authors based in Tanzania (orange nodes).*



Other institutions with at least two affiliated authors in the review include Nelson Mandela African Institute of Science and Technology (9), the University of Dodoma (5), the University of Arusha, Dar es Salaam Institute of Technology, Sebastian Kolowa Memorial University (SEKOMU), and St. Rock College of Early Education (2 authors each).

The distribution of authors affiliated with Tanzania-based institutions in Figure 3 suggests that there is a large and active research community around EdTech; however, the co-authorship network is quite fragmented, which may suggest that there is more scope for collaboration and network-building. Some of the most prominent Tanzania-based academics, who have authored multiple papers in the sample and have online profiles, are listed below.

4.1.1. Professor Joel S. Mtebe

Professor Mtebe is the most prolific author within the network, and he is central within the main cluster in Figure 4. Professor Mtebe is a Senior Lecturer (Associate Professor) in Computer Science at the Department of Computer Science and Engineering of the University of Dar es Salaam[12]; head of the UDSM eLearning Research Group (eLRG)[13]; and Director of the Center for Virtual Learning (CVL[14]).

The UDSM eLRG website lists Professor Mtebe's current research interests as "OER [open educational resources], MOOCs [massive open online courses], Cloud computing in education, usability of eLearning systems, Learning management systems, Mobile learning, and Information system success". Professor Mtebe was one of the authors of the critical review of EdTech in Tanzania which was included as a source in this review (↑Mtebe & Raphael, 2018a). He has published research on a wide range of EdTech-related topics; the papers selected for inclusion (note that HE-focused studies were excluded) in the literature review include teacher professional development (TPD) (↑Mtebe, et al., 2015a; ↑Mtebe, et al., 2015b; ↑Mtebe & Raphael, 2018b), constraints around uptake and use of EdTech in schools (↑Budoya, et al., 2019a; ↑Raphael & Mtebe, 2017; ↑Mtebe, et al., 2016), cloud computing for schools (↑Mwakisole, et al., 2018; ↑Mwakisole, et al., 2019), data mining from online learning systems in schools (the Halostudy system) (↑Mtebe & Kondoro, 2019), and agile approaches to EdTech development (↑Budoya, et al., 2019b). Examples of EdTech innovations that Professor Mtebe has published research on include, games-based learning (↑Godfrey & Mtebe, 2018), interactive physics

[12] http://elearning.udsm.ac.tz/index.php/academic-staff?view=employee&id=1
[13] http://elearning.udsm.ac.tz/index.php
[14] https://cvl.udsm.ac.tz/index.php/staff

experiments (↑Msoka, et al., 2015), and the use of digital diaries for parental engagement (↑Jeremiah & Mtebe, 2018).

4.1.2. Dr Mussa S. Kissaka

Dr Kissaka is also a member of the University of Dar es Salaam[15] and the UDSM eLRG, and part of the top right cluster in Figure 3. He is also part of the UDSM eLRG and is a Senior Lecturer in the Department of Electronics and Telecommunications Engineering, College of Information and Communication Technologies (CoICT), University of Dar es Salaam. His eLRG profile states that his research interests focus upon "Wireless Communication and e-Learning". Published papers within the literature review here include constraints around uptake and use of EdTech in schools (↑Budoya, et al., 2019a; ↑Mtebe, et al., 2016), TPD (↑Mtebe, et al., 2015a; ↑Mtebe, et al., 2015b;), cloud computing for schools (↑Mwakisole, et al., 2018; ↑Mwakisole, et al., 2019), agile approaches to EdTech development (↑Budoya, et al., 2019b), and interactive physics experiments (↑Msoka, et al., 2015).

4.1.3. Dr Ayoub C. Kafyulilo

Dr Kafyulilo is a member of Dar es Salaam University College of Education, University of Dar es Salaam[16]. His research interests focus on e-learning and educational technology (↑Kafyulilo, 2015), particularly in relation to TPD, including co-design of EdTech (↑Kafyulilo, et al., 2015; ↑Kafyulilo, et al., 2016), factors affecting teacher use of EdTech (↑Kafyulilo, et al., 2016; ↑Kafyulilo, 2014; ↑Kafyulilo & Keengwe, 2014), and TPD activities, including a focus on teachers Technological Pedagogical Content Knowledge (TPACK) (↑Kafyulilo, 2012; ↑Kafyulilo, et al., 2015; ↑Kafyulilo & Fisser, 2019).

4.1.4. Dr Christina Raphael

Dr Raphael is a Senior Lecturer at Dar es Salaam University College of Education, University of Dar es Salaam[17], and also a member of the UDSM eLRG. She has worked on several international projects, which align with priority areas for the EdTech Hub. Examples include a project focused on out of school children (OOSC) in Tanzania (2015–2016) funded by UNICEF (↑Ministry of Education Science and Technology, UNESCO and UNICEF, 2018), and currently the GATE (Gender Awareness and Transformation through Education) project, in collaboration with Trinity College Dublin[18]. Dr Raphael was one of the authors of the critical review of EdTech in Tanzania which was included as a source in this review (↑Mtebe & Raphael, 2018a). Further papers included in the

[15] http://www.elearning.udsm.ac.tz/index.php/academic-staff?view=employee&id=13
[16] https://www.researchgate.net/profile/Ayoub_Kafyulilo
[17] https://www.udsm.ac.tz/web/index.php/colleges/duce/staff/detail/Christina%20/535
[18] https://gateproject.net/dr-christina-raphael/

review focus upon EdTech and TPD (↑Mtebe & Raphael, 2018b; ↑Raphael & Mtebe, 2017).

4.1.5. Dr Vitalis A. Ndume

Dr Ndume is a Lecturer at Dar es Salaam Institute of Technology (DIT)[19]. Papers by Dr Ndume in the reviewed literature focus upon mobile learning, including factors around uptake in secondary schools (↑Chambo, et al., 2013) and use in mathematics (↑Ndume, et al., 2020).

4.1.6. Dr Patrick Kihoza

In the research literature sample, Dr Kihoza was affiliated with Nelson Mandela African Institute of Science and Technology. Dr Kihoza is currently a Lecturer in the Faculty of Science and Technology at Mzumbe University[20]. On his departmental profile, Dr Kihoza's research interests are listed as "ICT for development (ICT4D), E-learning and Blended learning application, design science research in educational technology, Software Engineering, Human-Computer Interaction, & User Experience, Information Technology projects dynamics, User-Centered design, Social Computing and Information and Knowledge Management". Papers by Dr Kihoza in the reviewed literature include a focus on problem-based learning (↑Roy, et al., 2012; ↑Roy, et al., 2014) and TPD (↑Kihoza, et al., 2016).

4.1.7. Dr Elia Kibga

Dr Kibga is a member of the EdTech Hub expert pool[21]. At the time of his most recent publication in the review, he was affiliated with the TIE. Papers by Dr Kibga in the reviewed literature focus upon EdTech and TPD (↑Mtebe, et al., 2015a; ↑Mtebe, et al., 2015b).

4.1.8. Aron W. Kondoro

Aron Kondoro is an Assistant Lecturer in the Computer Science and Engineering (CSE) Department at the University of Dar es Salaam[22]. Papers by Kondoro in the reviewed literature include using SMS to support TPD (↑Mtebe, et al., 2015a), and data mining from online learning systems in schools (↑Mtebe & Kondoro, 2019).

[19] https://www.researchgate.net/profile/Vitalis_Ndume
[20] https://fst.mzumbe.ac.tz/index.php/2016-09-12-11-04-57/computing-science-studies-css/staffs
[21] https://edtechhub.org/team/elia-kibga/
[22] https://www.researchgate.net/profile/Aron_Kondoro

4.1.9. Dr Hamisi Mfaume

Dr Mfaume is a Lecturer in the department of Educational Foundations, Management and Lifelong Learning, at Dar es Salaam University College of Education[23]. Papers by Dr Mfaume in the reviewed literature focus upon teachers use of mobile phones, for teaching (↑Mfaume, 2019) and TPD (↑Mfaume, et al., 2019).

4.2. EdTech research projects

Figure 3 also shows that EdTech in Tanzania has been the focus of international research. Clusters of researchers based in other countries are often associated with particular large-scale projects. For example, the green cluster at the top left of Figure 3 represents a group of academics based in Scandinavia and relates to a 'one laptop per child' (OLPC) project in Tanzania. The two clusters located in the bottom left, comprising academics in the USA and India, relate to the 'RoboTutor' project, which was undertaken as part of the XPRIZE (see Section 2 for background to the XPRIZE). Similarly, the smaller blue clusters towards the bottom left represent academics based in the Republic of Korea, presenting analysis of 'Kitkit school', also an XPRIZE finalist. Note that searches were also undertaken for other XPRIZE finalists, but published research could not be found at present.

In this section, an overview of some of the main large-scale EdTech projects undertaken with relevance for education of school-aged learners, the groups and individuals associated with the research, and links to related academic publications, will be introduced. Note that as the purpose of this section is to provide an overview of the stakeholders, the citation of literature in this section is for descriptive rather than analytical purposes. A closer look at the evidence of relevance to the EdTech Hub's five focus areas for future research will be undertaken in Section 5.

4.2.1. BridgeIT project

Tanzania was one of nine countries involved in the BridgeIT project. Partners included the Pearson Foundation, Nokia, International Youth Foundation (IYF), United Nations Development Programme (UNDP), and USAID. The main purpose of the project was to "Enhance teacher and school system capacity through comprehensive professional development, working closely with local partners and organizations on the ground to provide instructional support to teachers for primary-grade learning through guided curriculum and visual multimedia content" using mobile devices and television (↑Wagner, 2014, p.63).

[23] https://www.udsm.ac.tz/web/index.php/colleges/duce/staff/detail/Hamisi/542

Findings from the final report (↑Enge, 2011) are summarised on the HEART website as follows:

> "*Test scores of BridgeIT students in maths and science were significantly higher, 10–20%, compared to a control group; The distribution of mean scores, however, showed that many students were left behind; No significant gender differences were found in the test scores; Initially, teachers were sceptical about whether or not the videos would help students learn math and science, but this scepticism was drastically diminished by the end of the year; The teacher needs to help students to understand the video lessons for positive effects on test scores.*"[24]

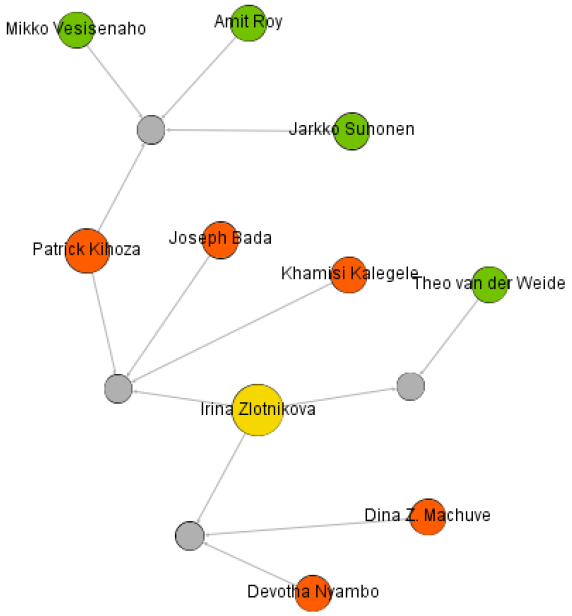
Although the project was undertaken early in the time period of literature reviewed, it has continued to be cited in the literature.

4.2.2. Worldreader

The goal of the Worldreader initiative is to "increase literacy rates around the world through the distribution of digital books on e-readers and mobile phones" (↑Wagner, 2014, p.132; see also ↑Read, 2015). Partners involved in their operations in Sub-Saharan Africa have included UNESCO, Amazon, Random House, and biNu (↑Wagner, 2014). Although Worldreader continues to operate today, the project within Tanzania was a focus for research in the mid-2010s, and two papers included in the research literature review relate to the project. Both are international collaborations, involving academics based in Botswana, the Netherlands, and Tanzania (Figure 5).

[24] https://www.heart-resources.org/doc_lib/elimu-kwa-teknolojia-bridgeit-program-summative-evaluation-executive-summary/

Figure 5. *Co-authorship network of authors and papers within the literature review, associated with research related to Worldreader.*



↑Machuve, et al. (2014) report on the monitoring and evaluation of e-readers project at two primary schools in Kikwe ward, where teachers reported perceived positive impacts upon student learning, particularly for SEND students. However, the evaluation was relatively small-scale and relied upon perceived impacts on learning.

While e-readers have been shown to be effective in other studies, their efficacy is mixed and depends on careful design of interventions (see the PRIMR project undertaken in Kenya; ↑Piper, et al., 2015). ↑Zlotnikova & van der Weide (2015) discuss and reflect upon some of the practical considerations for undertaking a 'community outreach project', using the e-readers project as a case study.

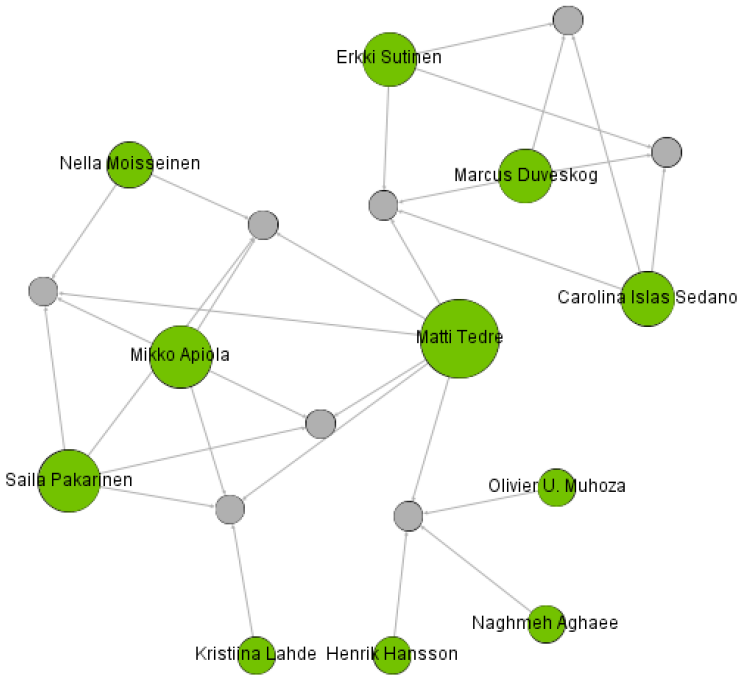
Further examples of the use of e-readers in Tanzania are reported in ↑Stanfield, et al., (2018), including a CAMFED project which distributed 1,300 Worldreader devices to 25 secondary schools, and a Christian Social Services Commission of Tanzania (CSSC) project involving e-reader use in 47 schools. ↑Stanfield, et al., (2018) discuss the benefits of the projects, and also challenges, and recommendations for future initiatives, linked to the principles for digital development.

4.2.3. One Laptop Per Child

A cluster of research articles report on projects using OLPC computers in Tanzania, shown in the top left of Figure 3, and in detail in Figure 6. The projects in the cluster were funded by grants from the Academy of Finland

and were collaboratively authored by academics based at HE institutions in Finland and Sweden.

Figure 6. *Co-authorship network of authors and papers within the literature review, associated with OLPC related research.*



The studies focus primarily on a rural Tanzanian school (Ukombozi Primary School) that received one hundred XO laptops in 2008. Note that investment in hardware alone has emerged consistently as a noted 'bad buy' (↑World Bank, 2020); in addition to the provision of hardware, the studies here also explore pedagogy and use in practice, and the authors are critical of the hardware design, for example:

> *"The XO laptop, specially designed for young learners in developing countries showed a number of short comings including the poor functionality of the mouse, difficulties in installing additional applications and the limited storage space, which raised several questions around the technology and its usefulness. Much time was spent on figuring out solutions on how to use the XO laptops for basic things such as showing recorded videos in the browser which would have been minor tasks on any other commercially available platform."* (↑Duveskog, et al., 2010, p.1)

↑Apiola, et al. (2011) describe how a focus on pedagogy was part of the project, which "developed student-centred, exploratory, and creative practices for classroom pedagogy, and we experimented on using individual (one-to-one) laptops as a support tool" (↑Apiola, et al., 2011, p.1). ↑Apiola, et al. (2013) and

↑Duveskog, et al. (2012) both look at the impact in relation to the pedagogical changes the initiative has instigated through digital storytelling and one-to-one computing. The initiative was found to be particularly helpful for promoting "exploratory and self-regulated learning, group problem solving, and constructive principles as facilitators of learning within the one-to-one computing paradigm in this context" (↑Pakarinen, et al., 2013, p.1).

In addition to the effects of using the technology, the group also reflected upon and developed research into the process of technology adoption around the OLPC project (↑Apiola, et al., 2012). The concept of 'living labs' was further developed as a model for co-creation of technology with communities more generally (↑Hooli, et al., 2016), and subsequently explored in a Human Development Innovation Fund (HDIF) project 'Making innovation work for girls and women in Tanzania' (↑Bangser, et al., 2017).

4.2.4. TZ21

The Tanzania 21st Century Basic Education Program (TZ21)[25] "was a five-year program spanning from the beginning of 2011 to the end of 2015, which aimed to improve children's reading ability in Standards 1 and 2 in Mtwara and Zanzibar, as well as to strengthen systems that support literacy development" (↑USAID, 2015, p.1), funded by USAID. In addition to demonstrating gains in children's literacy (↑USAID, 2015), the project also provided digital training kits for staff including class teachers, head teachers, mentor teachers and school inspectors across Tanzania[26].

4.2.5. GraphoGame

GraphoGame is a web-based interactive game, to improve children's literacy, initially developed in Finland, and subsequently adapted and trialled in several LMICs (↑Ojanen, et al., 2015). A trial of GraphoGame was piloted in Bagamoyo in Tanzania in 2015 with SEKOMU, which included "training teachers in synthetic phonics-based instruction methods, creating reading materials in Kiswahili and providing expertise in curriculum development" (↑Ojanen, et al., 2015, p.7).

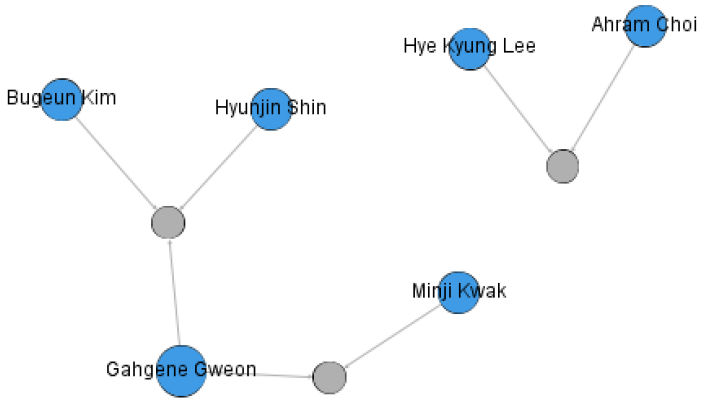
4.2.6. Kitkit School

Kitkit School was an XPRIZE finalist, and as a result of the field testing, was one of the two projects jointly awarded the prize (alongside onebillion). Kitkit School is part of enuma[27], which operates from Berkeley, USA and Seoul, South Korea. Kitkit School "developed a learning program with a game-based core

[25] http://crea-tz21.com/overview/
[26] https://www.iyfnet.org/initiatives/tanzania-21st-century-tz21
[27] For more information on enuma, see: https://enuma.com/

and flexible learning architecture aimed at helping children independently learn, irrespective of their knowledge, skill, and environment" (↑XPRIZE, 2019, p.4). Several papers and reports have focused upon the use of Kitkit school with Tanzanian learners, authored mainly by academics based in South Korea (Figure 7).

Figure 7. *Co-authorship network of authors and papers within the literature review, associated with Kitkit School related research.*



Kitkit school initially conducted a field study with a group of OOSC learners (n=38, September to December 2017), which showed post-test increases in relation to both literacy and numeracy (↑Kitkit School, 2017). In the XPRIZE field study, the learners who received Kitkit school software via tablets showed higher gains in comparison with the other finalists in terms of several metrics, in relation to literacy and numeracy (↑XPRIZE, 2019). ↑Lee & Choi (2020) present a randomised controlled trial to assess the different numeracy skills for two groups of learners (n=122, September to December 2017). The study found that learners in the intervention group who learnt through the tablet-based game enhanced their mathematical abilities in relation to recognising and naming numbers, addition, and counting forwards. Furthermore, game log data has also been used to examine whether making use of a 'digital scratchpad' assists learners in their use of the game, with the studies concluding that scratchpad use is associated with performance (↑Kwak & Gweon, 2019; ↑Shin, et al., 2020).

4.2.7. RoboTutor

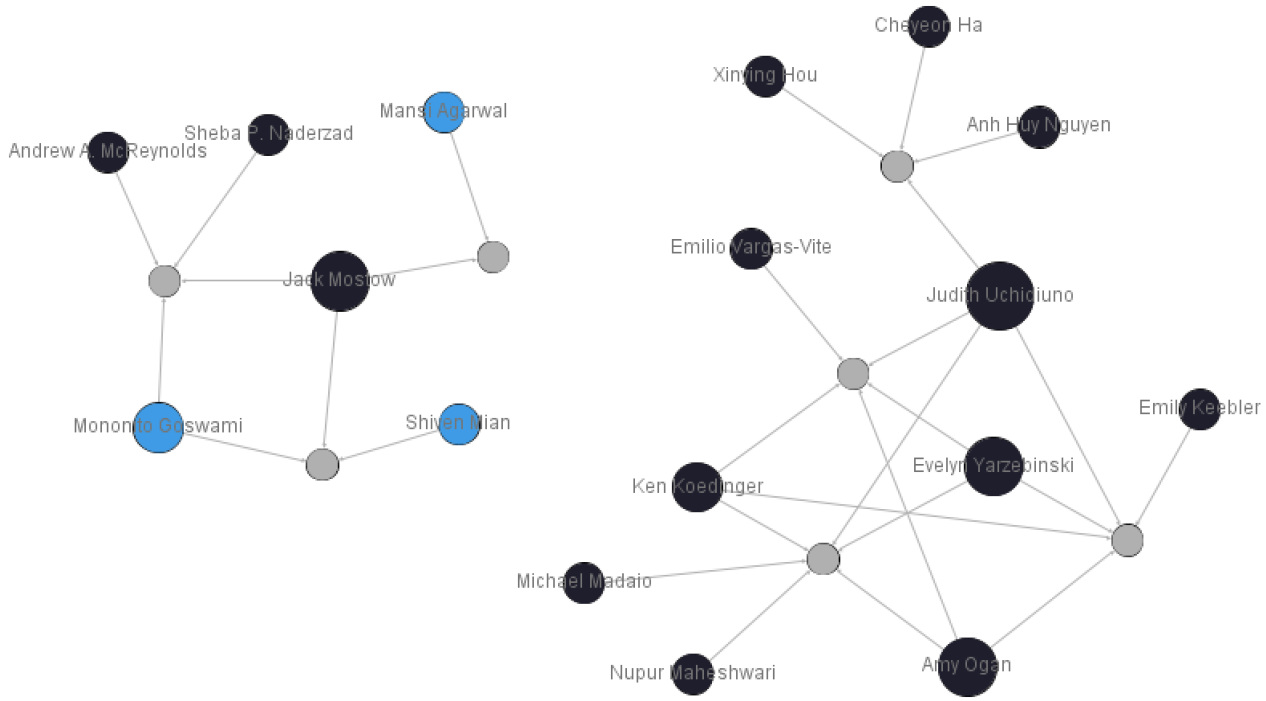
RoboTutor was also an XPRIZE finalist and took part in the Tanzania-based field testing. The RoboTutor software was developed by academics at Carnegie Mellon University in the USA; "RoboTutor leveraged Carnegie Mellon's research in reading and math tutors, speech recognition and synthesis, machine learning, educational data mining, cognitive psychology, and

human-computer interaction." (↑XPRIZE, 2019, p.4). The approach used by the RoboTutor software is a form of personalised adaptive learning:

> *"Each RoboTutor session consists of a series of activities selected by the child from a few reading, comprehension, or numeracy activities at his or her current level, with a sequence of items for the child to perform. RoboTutor adapts to each child by assessing performance automatically, providing individualized help and feedback, adjusting its estimate of his or her level, and proceeding accordingly."*[28]

Several academic papers have been published based on the research and experiences of RoboTutor and XPRIZE, primarily authored by academics at Carnegie Mellon, and some in collaboration with academics based in California, and Delhi, India (Figure 8). The papers address both methodological issues around designing and developing this form of technology, and how it has been used in practice.

Figure 8. *Co-authorship network of authors and papers within the literature review, associated with RoboTutor related research.*



Drawing upon their experiences of developing RoboTutor, ↑Goswami, et al. (2019) present a methodological paper introducing a tool that can be used to assist with developing intelligent tutoring software ('SPOT': statistical probe of tutoring). ↑Agarwal & Mostow (2020) present a technical proof-of-concept

[28] https://www.cmu.edu/scs/robotutor/what-is-robotutor/index.html

paper, demonstrating how facial expression data collected from Tanzanian learners using the tablet could be used as a training dataset to enable affective states to be used as a source of data for the intelligent tutoring system.

↑Uchidiuno, et al. (2018) present an analysis of observations undertaken to understand modes of engagement and interaction between learners, teachers, caregivers and their peers, in home and school settings. Further analysis of observations and interactions yielded context-appropriate design principles (↑Uchidiuno, et al., 2019a). The nature of peer support and interaction was further explored through a study that assigned students to particular roles (↑Uchidiuno, et al., 2019b). Focusing on the numeracy aspect of the software, ↑Ha, et al. (2020) analyse log data from learners in Tanzania particularly in relation to skip counting and pattern detection, and conclude that this is less effective and learners need to be better prepared for these tasks. An overall account of the assumptions, findings, and limitations of the XPRIZE field test are presented in ↑McReynolds, et al. (2020). Note that personalised learning is one of EdTech Hub's five focus areas, and RoboTutor will be discussed in further detail in Section 5.

4.2.8. onebillion

Alongside Kitkit School, onebillion also received the XPRIZE following the field test in Tanzania. onebillion offices are based in the UK and Kenya, and the software "merged numeracy content with new literacy material to offer directed learning and creative activities alongside continuous monitoring to respond to different children's needs" (↑XPRIZE, 2019, p.4). In the XPRIZE field tests, onebillion was frequently within the top two in terms of a range of literacy and numeracy learning gains (↑XPRIZE, 2019). Although no published academic research literature could be found yet from the Tanzania field test, research has been published based on its evaluation in other contexts[29].

4.2.9. Tusome Pamoja

The Tusome Pamoja ("Let's Read Together") programme began in 2016 and is set to conclude in 2021[30]. This large-scale programme is funded by USAID and led by RTI International. The principal goal of the programme is "to achieve improvement in age-appropriate, curriculum-defined levels of reading (with comprehension), writing, and mathematics at Standards 2 and 4 in the target areas", with a secondary aim to "develop, implement, and demonstrate best approaches to strengthen the quality of education in the target regions for replication consideration in other regions" (↑Sinno-Lai, 2018, p1.). This has included distribution of tablets to head teachers in participating schools,

[29] https://onebillion.org/impact/evidence/
[30] https://devtracker.fcdo.gov.uk/projects/US-GOV-1-AID-621-C-16-00003

linked to the Student Information System (↑Gavin, et al., 2018). Further information will be available when the programme concludes.

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

4.3.1. Cambridge Education

Cambridge Education (part of the Mott MacDonald group) have a wide portfolio of education and international development projects. The EQUIP-Tanzania project (EQUIP-T)[31] was a recent large-scale initiative, with EdTech components, funded by DFID (subsequently FCDO), with a focus upon improving learning outcomes — particularly for girls — within primary education.

4.3.2. CAMFED

CAMFED (Campaign for Female Education) is "is a pan-African movement, revolutionizing how girls' education is delivered". CAMFED aligns with the aims of the Hub as a proven cost-effective and equity-focused approach (↑Sabates, et al., 2018). The CAMFED Programme in Tanzania was identified as one of the most cost-effective approaches in the World Bank 'smart buys' report (↑Angrist, et al., 2020). While not exclusively focused on EdTech, examples of CAMFED projects in Tanzania that have used technology to support education include using mobile devices for data collection within communities (↑Girls Education Challenge, 2018; ↑REAL Centre, 2018), and the use of e-readers in schools (↑Stanfield, et al., 2018).

4.3.3. eLearning Research Group, University of Dar es Salaam

The eLearning Research Group (eLRG) is part of the University of Dar es Salaam (UDSM)[32]. It is a multi-disciplinary research group, including members from Computer Science, Electronics and Telecommunication, and Education (see also previous section for prominent members of the eLRG).

4.3.4. Human Development Innovation Fund

The Human Development Innovation Fund (HDIF) "is a £39.9 million UKAid-funded programme managed by Palladium International in partnership with KPMG, Newcastle University, and the Institute of

[31] https://www.camb-ed.com/intdev/article/559/changing-the-tempo
[32] http://elearning.udsm.ac.tz/

Development Studies (IDS)"[33]. 'Education' is a key part of its portfolio; related EdTech interventions include Ubongo, Shule Direct, and an e-learning platform[34]. In collaboration with researchers from Newcastle University, HDIF recently published a report (identified through the literature review) entitled 'EdTech innovations in Tanzania: Investigating student and teacher perceptions' (↑Stanfield, et al., 2018).

4.3.5. RISE Programme

Research on Improving Systems of Education (RISE) is an international research programme with a focus on investigating how education systems can overcome the learning crisis[35]. Tanzania is the location of one of the programmes' core research teams.

4.3.6. Tech hubs

Although not specifically education-focused, there is a modest, but thriving tech hub ecosystem in Dar es Salaam. These hubs act as accelerators, incubators and co-working spaces for early-stage tech companies and include Sahara Ventures, Seedspace, Magilatech, Silicon Dar, and the government-linked Buni Hub. An EdTech example is Ubongo Kidz, which was supported through Buni Hub in its earlier stages (↑Seppälä, 2016).

4.3.7. TETEA

TETEA is a non-profit organisation with a broad goal "to empower Tanzanians through education"[36]. The TETEA portfolio includes building and supporting libraries, a scholarship programme, Maktaba online resources, and the TextTETEA project. Through the TextTETEA project, SMS is used as a way to share educational information and resources (a paper about the project was identified through the research literature review; ↑Neumann & Wincewicz, 2016).

[33] https://hdif-tz.org/
[34] https://hdif-tz.org/educations/
[35] https://riseprogramme.org/
[36] https://www.tetea.org/about-us/

5. Summary of the academic evidence on EdTech

The purpose of this section is to present the most significant gaps in evidence, highlighting potential opportunities for future research. The literature is thematically analysed and organised into five focus areas of interest to the EdTech Hub:

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

Within each focus area, the existing research literature will be summarised and some of the most promising evidence gaps and areas for future research will be identified.

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

The first focus area addressed within the research literature relates to the use of technology to support personalised learning. There is an existing body of research literature that demonstrates that EdTech which adapts to the level of the learner — such as intelligent tutoring systems — can be an effective way to improve learning outcomes in LMICs (↑Major, et al., forthcoming; ↑Muralidharan, et al., 2019). By adapting to the learners' level, this type of approach can potentially be particularly useful in mitigating the effects of large class sizes and high ratios of learners to qualified teachers (↑Büchel, et al., 2020). Furthermore, personalised learning can also be cost-effective; "Using software that adapts to the learning level of the child (where hardware is already in schools)" is a 'Good buy' (↑World Bank, 2020, p.14). However, the report cautions that it is critical to consider contextual factors in order for personalised learning to be successful:

> *"An important caveat is that this approach is relevant only where electricity, internet connection, teacher training, and widespread availability of hardware—including lower-tech devices in the home—make this doable at low cost and in a way that is inclusive, and*

> *where the software has been shown to be well-designed for learning. This intervention has more evidence from high-income contexts and needs more evidence related to its use in LICs. There is less evidence at scale for this intervention than for others in this category, but it is included here because it is a very promising mechanism for implementing a well-supported Good Buy (teaching at the right level); also, there is now an explosion of innovation in this area that should soon yield more evidence, helping to assess its effectiveness."* ↑World Bank, (2020), p.14

While personalised learning offers potential benefits, there is currently a gap in terms of understanding how it could be used at scale in Tanzania, which would warrant further research. As noted in the contextual statement in the Smart Buys report (above), the approach is contingent upon assumed levels of electrification, connectivity, hardware, and teacher training. Access to hardware was a focus of some of the 1:1 computing projects — such as OLPC and e-readers discussed in Section 4 — and findings around sustainability (↑Apiola, et al., 2012; ↑Zlotnikova & van der Weide, 2015) and relationship to classroom pedagogy (↑Pakarinen, et al., 2013) would also be applicable here.

There is a small but growing body of research evidence into personalised learning in Tanzania, with high-profile projects recently publishing findings. Two of the XPRIZE finalists are examples of applications using personalised learning. RoboTutor is an intelligent tutoring system[37], while onebillion's 'onecourse' app adapts to the learner's level[38]. Overall, the average effect across all five products was that "children were able to learn the equivalent of a year's worth of full-time school on an average of one hour a day in our field trial." (↑XPRIZE, 2019, p.8). It is important to note that building infrastructure — such as installing solar panels — was included in the field trial.

No published research specific to the onebillion field trial appears to be available yet (reports are available from other contexts, such as Malawi; see previous section); however, a group of articles were identified which report upon RoboTutor in Tanzania. A summary of all the RoboTutor papers can be found in Section 4 and included technical papers for designing an intelligent tutoring system and observations of its use in practice in Tanzania.

The overall findings from the RoboTutor field trial are summarised by ↑McReynolds, et al. (2020), who provide an overview of the field test experience and its learning outcomes. Overall, the team reflect that some of their basic assumptions about implementing the systems — including availability of electrical power, internet connectivity and WiFi, power and availability of

[37] https://www.cmu.edu/scs/robotutor/what-is-robotutor/index.html
[38] https://onebillion.org/onecourse/app/

computers and sensors, and support — were proved to be inaccurate through the field trial. The article first draws upon pooled data from the five XPRIZE finalist trials (not RoboTutor alone), which was carried out over 15 months in 168 villages in Tanzania, and comprised a large sample size (treatment n=1680; control n=361), with the majority of learners being aged nine to eleven years old. Overall, in comparison with the treatment group, learning gains for the treatment group "averaged 2–3x higher, ranging from 18% (sd 16%) to 26% (sd 17%) [...] the five Finalists' apps beat the control group not just significantly ($p < .000$ on unpaired T-tests, $n = 2041$) but dramatically (effect size .82)" (↑McReynolds, et al., 2020, p.179). RoboTutor-specific data is provided for 166 learners who continued to use the app after one year; most of the measures were associated with positive gains (see Table 3 in↑McReynolds, et al. (2020), for specific measures).

In addition to measures of learning gains in relation to numeracy (EGMA) and literacy (EGRA), a social-emotional assessment was also carried out at the baseline, midline, and endline of the XPRIZE study. However, "the XPRIZE apps had little of the hoped-for impact on [social-emotional] measures, unlike their dramatic impact on learning gains" (↑McReynolds, et al., 2020, p.180).

Although the onebillion and RoboTutor field tests provide strong evidence to suggest that personalised learning software can lead to improvements in learning outcomes, there are several areas where further research would be useful in order to help inform how these approaches could be used at scale. The existing research has focused upon learning outcomes in terms of reading and numeracy skills, with young learners; there is a gap in relation to other outcomes and age groups. Questions also remain about the practicalities of scaling, ensuring that access to hardware does not exacerbate inequalities and that interventions are contextually appropriate. Use of personalised apps for learning also raises questions about their relationship to classroom pedagogy and the role of teachers; note that this also relates to the 'teaching at the right level' approach, which was also identified in the 'smart buys' report.

5.2. (In-service) teacher professional development, structured pedagogy and technology

The second of the Hub's five focus areas focuses upon teachers, including in-service TPD, structured pedagogy and technology. A 2008 baseline study conducted by UNICEF examined the provision of INSET (in-service education and training). ↑Hardman, et al. (2011) summarise the study, which found:

> *"... an absence of strategic planning, coherent policies, regular provision and monitoring of INSET, and confusion between the central and local*

> *governments over roles and responsibilities with regard to teacher employment, professional development and accountability for performance. Where it did take place, INSET often took the form of government-supported certificate upgrading rather than school-based INSET and workshops focusing on pedagogy.*" (p.674)

Recommendations from this study catalysed a shift towards school-based professional development opportunities for teachers which followed established pedagogical approaches such as reflective practice, alongside "flexible modes of delivery to meet local conditions" with "paper-based and online distance learning materials, and face-to-face meetings with tutors and cluster meetings of teachers" (↑Hardman, et al., 2011, p.676). In short, blended and flexible approaches to TPD are viewed as a means of ensuring effective national INSET coverage at the systems level.

Blended, hybrid approaches were further identified by EdTech Hub as being the most appropriate for CPD (continual professional development) for teachers in Tanzania.

- Outlining various CPD modalities, ↑Adam, et al. (2021) draw upon research evidence to emphasise that the most effective approach is to incorporate multiple modalities together in a hybrid approach.
- When considering this hybrid approach, a school-based teacher learning group model is recommended. The core element of this model is a community of learning modality, supplemented by other modalities, namely workshops for peer-facilitators of the group, support from external coaches and semi-structured facilitator guide notes.
- A hybrid school-based CPD model leads to effective changes in teaching practices.
- The ongoing nature of the communities of learning modality allows for teachers to reflect on new pedagogies and content, to gradually and experientially adopt new approaches for their content. Furthermore, it allows teachers to guide their own development, provides time to practice introduced techniques and allows teachers to share experiences and challenges with colleagues.
- The tech-enabled school-based teacher learning group model is designed for low-resource contexts as it only requires one tablet per school as a minimum. A drawback of the model is its effectiveness depends on the quality of peer facilitators and the support and guidance given to them.
- Crucially, the effectiveness of any modality depends on the context and quality of its implementation. It is important to consider wider enabling

conditions to increase the potential effectiveness, relevance and sustainability of the programme (↑Adam, et al., 2021).

↑Ngeze & Iyer (2019) tested out an online TPD initiative with 134 Tanzanian teachers across Tanzania via Moodle. The aim of this study was to assess the potential of online TPD to support the scaling up of teacher learning across Tanzania, alongside face-to-face delivery. The study found that teachers did translate the learning from the online course into their teaching practice, with further positive effects including the growth of a professional learning community for teachers to engage in (↑Ngeze & Iyer, 2019). The authors also acknowledge the need for a multimodal approach to support the harder-to-reach teachers who may not have consistent or reliable access to the internet. Data suggests that mobile phones could have potential here, with the data in Annex A showing high mobile penetration in Tanzania.

↑Mtebe, et al. (2015a) explore the potential for mobile technology to support effective TPD, through the use of SMS quizzes to develop teachers' (n=486) subject content knowledge in mathematics, physics, chemistry and physics. Chemistry and biology teachers performed more strongly in the SMS quizzes, also seeing consistent high levels of non-response from the mathematics teachers (↑Mtebe, et al., 2015a). A particularly interesting finding from this study is located within a survey collating teachers' perceptions of the SMS-based tool for TPD. 55% of teachers (n= 266) responded, with 85% of the respondents stating that "the SMS quiz exercise did not help them to improve their knowledge and skills to teach their subjects" (↑ibid, p.3898). ↑Mtebe, et al. (2015a) conclude that "mobile phones can be used as tools to enhance teaching and learning in rural secondary schools" (p.3901) in Tanzania. This study outlines clear challenges to the potential effectiveness of mobile technology in enhancing teachers' capacities, especially when considering teachers' own perceptions of this project's impact on their practice. As such, high mobile phone penetration does not guarantee that the use of mobile technology will have a positive effect on teacher learning and classroom practice.

Teachers' perceptions and needs in relation to TPD are diverse, and this must be taken into account when designing and implementing contextually appropriate learning programmes. Contextual variations could mean the divergences between urban and rural schools. Regarding technology adoption in remote Tanzanian schools specifically, ↑Pima (2019) gives four 'motivating factors', namely: 1) teachers' experience in using digital technologies; 2) the existing technologies present in a teacher's local context; 3) the expected benefits of using digital technologies to support teaching and learning; and, 4)

the teacher's perception that digital technologies can help meet set learning objectives.

In terms of Pima's second 'motivating factor' of the existing technologies present in a given context, ↑Stanfield, et al. (2018) state Tanzanian schools can often "lack the required infrastructure and facilities to enable an Edtech innovation to be implemented and sustained in the long run" (p.9). Infrastructural constraints must be at the forefront of any decision relating to EdTech in Tanzania, and teachers' access to existing technologies must be part of this consideration when zooming in on tech-supported TPD. There has often been a gap between the rhetoric of ICT policy at the national level and the realities of available technologies in certain schools which restricts the ability to enact policies at the local level (↑Muhoza, et al., 2014). ↑Muhoza, et al. (2014) found that teachers have been filling these gaps through proactive communication with their peers to achieve effective technology use in the classroom, a finding ↑Manyama (2017) also spoke to around the organic establishment of professional learning networks. These bottom-up peer support networks are vital to a functioning and lean system that is responsive to teachers' different contexts; ways in which the system as a whole can learn from these networks and integrate any of these learnings in delivering tech-supported TPD at scale could be an interesting avenue for EdTech decision-makers to consider.

Materials such as OER can lend themselves to adaptation to different contexts. In exploring the relationship between teacher educators and OER in a comparative study across Mauritius, Uganda, and Tanzania, ↑Wolfenden, et al. (2017) mention the leading role of the TESSA (Teacher Education in Sub-Saharan Africa) programme — which provides free OER that support national curricula.[39] This engagement in OER has meant that educators in Tanzania regularly attend workshops on OER (↑Wolfenden, et al., 2017), and a dedicated OER policy has also been developed by the ↑Open University of Tanzania (OUT) (2016). For educators to be more effective in their use of OER, agency is acknowledged to be a core component, while structural or contextual factors can often inhibit agency. It is when educators have the space to locate, modify and create their own resources that knowledge can be embedded around effective use. ↑Wolfenden, et al. (2017) argue allowing educators the time and space to explore OER, develop their digital literacy, and engage in professional dialogue with other educators can be beneficial for their practice.

[39] http://www.tessafrica.net/

Teachers' technology adoption, or more broadly, teachers' access to and use of technology in and outside of the classroom, was a frequently researched topic within this focus area. Several studies which discuss teachers' technology adoption view mobile phones as significant devices which can enhance Tanzanian teachers' access and use of technology, potentially promoting more effective TPD in the process. ↑Mfaume, et al. (2019) found that mobiles could improve teachers' professional accountability by enabling the TSC to reach teachers en masse, and, in the same vein, by enabling teachers to contact the TSC. Teachers within this study also reported further benefits of mobile technology, such as ease of use, wide internet coverage, and relative ubiquity across the country (↑ibid.). However, despite the acknowledged potential of mobile technology to support effective teacher learning and improved teaching practice (↑Todd, 2020b), ↑Msuya (2015) found that the majority of secondary school teachers who participated in the study did not use their phones (smartphones in this instance) for educational purposes; this finding is corroborated by a separate study by ↑Mfaume (2019), and ↑Joyce-Gibbons, et al. (2018) who comment on the need to engage students, teachers and wider communities in discussions around the introduction of mobile technologies within the classroom to address any concerns and communicate the potential benefits. Thus, though there are clear advantages in leveraging mobile technology to support TPD, in-classroom teaching, and student learning, there remain various constraints that must be considered in order to make effective use of this technology.

Technology adoption by teachers' in Tanzania is fairly high, with high levels of mobile technology penetration in particular. However, effective use of digital technologies by teachers in the classroom remains a challenge. This challenge can be addressed by focusing on TPD programmes which comprise the core characteristics of effective teacher learning, such as peer learning, promoting reflective practice, and encouraging the practical application of teaching methods that can be of direct use in the classroom. Furthermore, the ongoing, continuous nature of professional development to support teachers' sustained adoption and effective use of technology must be established (↑Stanfield, et al., 2018).

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

Data use is a key part of education systems; having access to timely and accurate data showing the status of the education system is crucial for policymakers in order to be able to respond quickly and effectively to emerging challenges and understand appropriate interventions. Technology

can be utilised to improve the data collection and data usage that informs effective decision-making in education.

Tanzania joined the Open Government Partnership Initiative in September 2011 and committed the government to establishing an open data portal[40] that would release key datasets in the education, health, and water sectors in machine-readable form. Key indicators are uploaded in Opendata and verified by Independent Verification yearly. The Open Data Barometer highlights that Tanzania is a leading country in sub-Saharan Africa in relation to Open Data, and particularly strong in relation to education data[41]. Two open data projects — the Education Open Data Dashboard[42], a government project established by the Tanzania Open Data Initiative (supported by the World Bank and DFID), and Shule (shule.info), spearheaded by Arnold Minde, a private citizen — are examples of recently initiated education projects referred to in the literature (↑Verhulst & Young, 2017).

In a recent push to improve the delivery of public services, a number of government institutions in Tanzania have been implementing various IT systems. With the support of the Education Programme for Results (EPforR), the President's Office — Regional Administration and Local Government (PO-RALG) have developed IT systems to improve the delivery of basic education services in Tanzania — under the Director of ICT. A team based in the PO-RALG recently developed and instituted an updated SIS, which "is a daily school reporting mobile information system, that enables instant data collection for school characteristics, daily classroom attendance, evaluation and behavior, teacher and staff distribution, initial enrollment and generates an identification code for each student"[43]. Ambitions for technical development in the future include increasing efficiency and effectiveness through further integration of digital systems, including systems to enhance teacher deployment.

A recent report documented the impact of some of these systems, asking questions on the cost:benefit ratio of these digital systems, the value of digitisation in the education sector, whether there are better alternatives, and how the implementation/benefits of these systems could be optimised for future projects (↑Mtebe, 2020). This study was conducted at initial stages of the implementation of IT systems and covered about 18 stakeholders. However, the study did point out the need to consolidate systems across various departments and having standardised tools across systems. They also found that the IT systems enabled the PO-RALG to improve the quality of collected

[40] http://opendata.go.tz
[41] https://opendatabarometer.org/4thedition/regional-snapshot/sub-saharan-africa/
[42] https://educationdashboard.org/
[43] http://196.192.74.42/PoralgSite/

data in terms of accuracy, completeness, and errors in addition to reducing costs of data procurement and management. It should be noted that the widespread use of sustained Per Diems has been a way in which these very capable teams has been recruited, so undertaking reform without payment of Per Diems will present challenges (↑Mtebe, 2020).

5.4. Technology to promote participation in school

This focus area centres on using technology to promote participation in school. The literature review identified two main topics addressed within this focus area; the use of positive messaging, and supporting accountability between parents and schools.

Positive messaging describes sharing information — about the benefits of school, and ways to receive support for sending children to school, such as funding — in order to encourage parents and their children to participate in school-based education. In Tanzania, 1,434,649 children were recorded as OOSC in 2019 (see Annex A). Positive messaging emerged as the only 'great buy' in the World Bank 'Smart Buys' report (↑World Bank, 2020), associated with an average of approximately 15 LAYS per $100 (↑Angrist, et al., 2020). Considerations for effective use of positive messaging include:

> "*This can be effective where specific, locally relevant information of decent quality from a trusted source is available. The delivery method of the information (for example, text messages or meetings) must be tailored to the country's specific needs. Also, recipients must have the means to act on the information; for example, there must be schools nearby so that families who are inspired to keep their girls in school are able to do so safely; and communities that receive the information need to have enough access to decision-making structures that they can spur action.*" ↑World Bank (2020), p.11.

There is clearly potential for technology to be used as a medium to implement positive messaging strategies at scale; for example, the Smart Buys report cites examples of using video and apps, in Chile and Peru (↑Neilson, et al., 2015; ↑Neilson, 2019). However, there are open questions of how different types of technology could be used most effectively, in ways that are contextually appropriate. ↑Solomon & Zeitlin (2019) report the findings from a recent survey of parents in Tanzania, to explore the types of information that parents would find valuable in relation to school choice, and would thus be helpful to include in a messaging campaign.

In terms of the technology which could be used to support positive messaging, high mobile phone usage with Tanzania (Annex A) and existing

research literature suggest that this may be a useful medium. For example, ↑Neumann & Wincewicz (2016) describe the model of 'TextTETEA', which was developed in order to deliver educational content to learners via SMS. The potential for smartphones to be used to enhance parental engagement is explored by ↑Jeremiah & Mtebe (2018), through the use of a 'digital diary' app to communicate between schools and parents. While mobile phones would appear to be a good candidate for communicating positive messaging, there is a gap around other potential channels (such as television) and questions about possible trade-offs between scale and efficacy of broadcast media versus more targeted approaches.

The second way in which technology can be used to promote participation in school focuses on its use to help foster greater accountability for progress between schools and parents and caregivers. In the 'Smart Buys' report, "Community involvement in school management" was noted as a 'promising but low evidence' approach at present (↑World Bank, 2020, p.17). ↑Cilliers, et al., (2019) reported positive outcomes, particularly for the lowest performing schools, of the 'Big Results Now in Education' programme in Tanzania. Schools in Tanzania have been organising parent meetings, talking with parents on the phone, and visiting parents' homes as strategies to enhance parental school involvement in their child's education. Some schools have also been sending bulletins, letters, and paper-based diaries with information such as test results, announcements, and children behaviour in order to increase parental involvement in schools. However, parental involvement has often been low. For example, a study conducted in 20 schools with 222 children in Dar es Salaam in 2012 found that 56% of parents were neither helping children in doing homework nor attending parent meetings (↑Twaweza, 2012).

Part of the recent EQUIP-T qualitative evaluation focused upon community engagement, in order to understand how successful — and why — the recent adoption of parent-teacher partnerships (PTP) has been. PTPs are "*class-based groups of parents and teachers intended to bring parents closer to the classroom*" (↑Ruddle, et al., 2020, p.ii). The study uncovered variation in practice around PTPs, underscoring the importance of context and keeping parents informed about new initiatives:

> *"Even though schools were selected to analyse PTP best practice, this study finds variable evidence of what best practice means in each of these schools. Schools had variable experiences of selecting, training, and engaging PTP members. Schools visited at endline followed different processes to select PTP members – in some cases parents nominated themselves through a formal application, in others the head teacher and SC nominated a set of candidates and then opened up the selection process to parents. Parents are likely to have had the least*

> *voice in selection because they did not have enough information about the role and function of the PTP at the time of choosing members to make an informed choice. Although the structure is voluntary and accessible to all parents, the study finds that those parents with better socio-economic status or more influence in the community were favoured as PTP members.*" (↑Ruddle, et al., 2020, p.iii)

Mobile devices have potential to be used to support accountability between schools and parents. Although there is emerging evidence that suggests that this could be beneficial, evidence is limited and restricted to the proof-of-concept level at present. ↑Jeremiah & Mtebe (2018) present a study in which a digital diary is a tool for enhancing parental involvement in children's academic life. The digital diary was piloted at one school involving 7 teachers and 156 parents using both qualitative and quantitative research methods. A majority of parents perceived that using a digital diary would enhance their involvement in their children's school-related activities, and mothers were far more involved with children's school-related activities as compared to fathers (↑Jeremiah & Mtebe, 2018). This study was conducted over a period of 6 months, and the novelty of use needs to be disaggregated from long-term usage of digital diaries. While this study suggests that this type of approach has potential, the use of digital diaries would need to be explored further and in a wider range of contexts.

5.5. Girls' education and technology

The final focus area is centred on how girls' education can be promoted and supported through the use of EdTech. Improving access to education for girls is key to achieving sustainable development (↑GEM, 2020). While technology can be used to address gender equity, its use can also risk exacerbating inequalities. This focus area addresses this issue, presenting a summary of research evidence on the impact of EdTech on girls' education in Tanzania.

Working toward equal participation in education regardless of gender has been a focal point for initiatives and policy in the past (↑Okkolin, et al., 2010), and enrolment rates are now equal within school-based education (Section 2). However, while improvements to enrolment rates are a positive step, there is scope for further support to ensure that rural and urban divides do not persist, and that increased participation results in equal attainment (↑Al-Samarrai & Tamagnan, 2019) and longer term empowerment of girls (for example, through girls clubs; ↑Unterhalter & Heslop, 2012). The CAMFED programme in Tanzania (↑Sabates, et al., 2018) has been identified as providing effective returns upon investment in terms of 'Learning Adjusted Years of Schooling' (LAYS). It is "a

program that provides scholarships for girls along with school materials and training for teachers and parents (1.1 LAYS)" (↑Angrist, et al., 2020, p.15).

However, the potential role for technology to support girls education remains under-explored. Girls education was not a primary focus of any of the papers included in the literature review, and there is currently a gap in relation to EdTech and girls education in Tanzania (↑Webb, et al., 2020). The current review did uncover several studies of EdTech interventions which do not exacerbate gender inequality; that is, examples which reported no significant differences in learning gains according to gender. In an example focused upon educational television, ↑Borzekowski (2018) conducted a quasi-experimental study involving 568 children aged three to six, to examine the efficacy of *Akili and Me* in comparison with other television programmes. Watching *Akili and Me* was associated with "significantly improved drawing skills, shape knowledge, number recognition, counting, and English skills" (↑Borzekowski, 2018, p.53), and no significant differences in achievement were observed according to gender.

Evidence from two of the XPRIZE finalists — RoboTutor and onebillion, both being tutoring software systems — also suggest that the use of this technology is beneficial to both girls and boys, in early grades at least. In the XPRIZE field study, no difference was found in achievement between boys and girls when using the RoboTutor software (↑McReynolds, et al., 2020). Although the onebillion Tanzania study does not appear to have been published yet, papers from other contexts show positive results in relation to gender. ↑Pitchford, et al. (2019) conducted a series of experiments with learners in Malawi, first to examine gender differences in relation to standard practice, and then using onebillion apps to support mathematics, and reading. Sample sizes ranged from 256 to 2,017 Grade 1 and 2 learners (ages ranged from six to eight years old) across the three experiments. The first experiment confirmed patterns observed in SACMEQ data; that is, that boys' learning gains are greater than girls and that the gap becomes more pronounced between Grades 1 and 2. Data from EGRA and EGMA assessments in the second and third experiments show that this gap was closed in the groups which received the intervention (↑Pitchford, et al., 2019). While this study suggests that this type of technology can be used to prevent gender gaps emerging, at early grades, there is an open question of whether apps would have similar effects for older learners, or could be used to close gaps that have already emerged. Furthermore, it should be cautioned that outside of trial conditions, gender differences may exist in terms of access to technology.

This gap in the literature may indicate that there could be scope for EdTech to be used in other ways which have not yet been explored, to support beneficial models such as girls clubs (↑Unterhalter & Heslop, 2012) or elements of the

CAMFED Programme (↑Sabates, et al., 2018) at a wider scale. As this literature review focused specifically upon EdTech, there would also be value in further examination of research related to girls education initiatives (not specifically EdTech-focused) as follow-on research, to examine the potential for non-EdTech-based models to be adapted for scale through technology.

6. Summary of political economy analysis

This analysis was completed before the death of the serving President, John Pombe Joseph Magufuli on 17th March 2021. Given the amount of power centralised to the president and the president's office, the political economy will likely change over the coming weeks and months. However, the broad trends outlined are likely to continue in at least the short to medium term.

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

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

The analysis has combined desk-based research with anonymous and informal interviews with eight influential individuals (referred to as participants) in the Tanzanian education system: across donors, government, researchers and think tanks. The analysis specifically looks at:

- The government education system (as opposed to private alternatives),
- Primary and secondary levels,
- The role of evidence in relation to EdTech,
- The political economy at this point in time — ahead of the 2020–2025 Magufuli presidency (rather than looking at the political economy across election cycles).

A stakeholder mapping exercise was undertaken — looking at the different stakeholders across the system — detailed in Annex D.

6.1. EdTech drivers of reform and decision-making

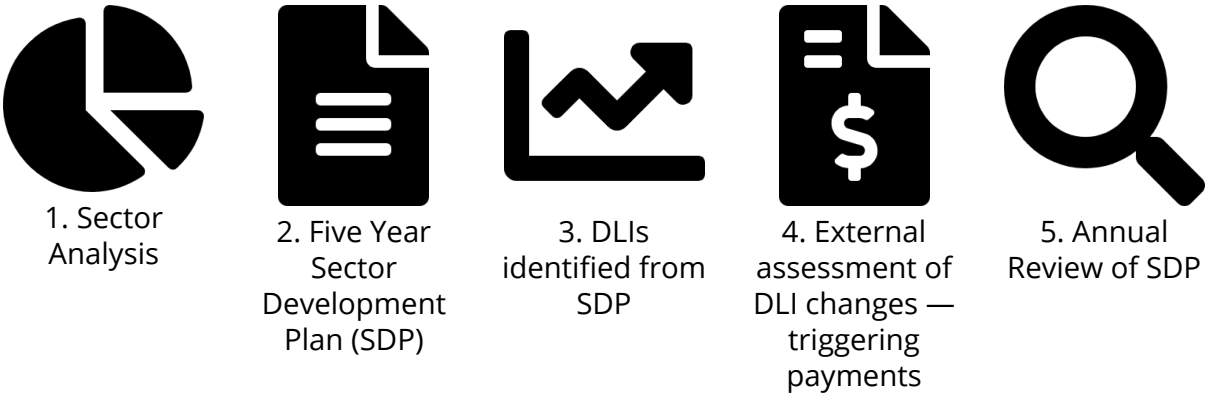
This section uses input from the interviews and also desk-based research. Three main drivers were identified: the donor funding cycle and the Five Year

Sector Development Plan; direction of the president and central government; and the role of influential figures.

6.1.1. Donor funding cycle and the Five Year Sector Development Plan

Education is mainly funded through domestic sources, however as most funds are spent on recurrent costs, donor funding to the government makes up a significant investment into the government's education development funds — 44% in 2017 and 29% in 2018 (↑UNICEF Tanzania, 2018). The Education Payment for Results (EP4R) mechanism is the most significant support to the government from donors. The donors supporting this mechanism (in the reported order of magnitude) are The World Bank, FCDO, SIDA, Global Partnership for Education (GPE) and Korea International Cooperation Agency (KOICA) (↑DFID, 2020). This funding is, at least theoretically, aligned across the major donors and government. The cycle of this process is a key way that evidence is used within government reform. The cycle broadly follows the GPE cycle (detailed in Figure 9), but it is not an exact science, given the different political drivers within donor organisations. For example, the latest set of disbursement linked indicators (DLIs) has been identified ahead of the Sector Development plan — due to donor programming schedules.

Figure 9. *GPE-linked donor funding cycle.*



This process is influential because it has significant funding attached to it — with participants reporting over $500 million earmarked for funding across three of the donors over the next 5 years. The DLIs have become a high priority for the government because achieving the results releases further funding. Donors also provide support in the form of programmes to support the implementation of these DLIs, which can be successful in their alignment to government priorities. This approach has demonstrably achieved change — as

noted through the EQUIP-T evaluation showing "a substantial positive impact on learning outcomes" (↑Ruddle & Rawle, 2020, p.ii).

Participants noted that the funding cycle is still quite donor-driven, but that it has become much more government-led (and less donor-driven) over the last 5 years. The funding cycle has driven sustained and significant change from within the government — with genuine government ownership. However, it was also noted that donor-driven changes cannot be expected to last beyond the funding process, without genuine government buy-in.

One of the participants noted that the donor programmes, which are often popular with government officials, are those that are 'hands off' and allow the government a level of decision-making. The GPE Lanes programme was cited within the interviews as a popular example with the government — and the evaluation showed "significant positive results" (↑Connal, et al., 2018, p.18).

6.1.2. Direction of the president and central government

Given the centralised power within the government, the President and the central government has significant power to catalyse or influence reform. This central direction needs to be considered, especially within EdTech, as often this central direction will directly support or hinder EdTech reform. This power is broadly wielded in the following five ways:

- **Signature and central policies**. The central government has high profile signature policies, which become high priority within the education system. An example of this is the fee-free education policy that Magufuli introduced (↑Languille, 2019; ↑Murgo & Jaffer, 2016). Another example is the Education and Training Policy, which is the roadmap across the education system, from pre-primary to further education, and sets the overarching philosophy and the key parameters (↑Ministry of Education and Vocational Training, 2009). This policy is held centrally — signed off by the president — and parliament.
- **Informal statements and recommendations**. President Magufuli often suggested changes in relation to education through public interviews. Although these statements did not always lead directly to policy change, they added to the complex political economy of reform. Examples of these are comments around pregnant girls returning to schools and the teachers right to use corporal punishment of students (↑AfricaNews, 2019; ↑Boyd & Burrill, 2020; ↑Gladys & Alex, 2019). One participant noted that sometimes the policies don't change, but instead, the profile of the policies is lowered. All participants noted the impact of these

presidential statements, so they should not be overlooked when considering decision-making.

- **Election pledges**. Manifesto commitments lead to a top-down direction for change and set the direction for reform. For example, there was an informal election pledge in the 2020 election to hire 13,000 extra teachers. Further, there was a significant pledge — formally in the manifesto — to give all secondary schools computers and connectivity (↑Chama Cha Mapinduzi, 2020). It was noted that both civil servants and ministers often emphasise that they are focused on delivering the manifesto.
- **Broad government direction**. Reform also filters into the education system through the broad direction of the government — outside of the specific education sector. The most notable of these in relation to EdTech is the push for new technology and increased infrastructure (↑Eriksen, 2018). Another example is the broad support for school building infrastructure. The result of which is that most of the government development funds are allocated to classroom construction and renovation (↑UNICEF Tanzania, 2018). Given this broad central push — it is likely that officials at all levels will support these types of projects. This may add challenges to vital components to utilise infrastructure — which may be overlooked.
- **Hiring and firing of staff**. The President has the power to hire and fire senior education officials — such as the Deputy Permanent Secretary (↑The Citizen, 2020).

6.1.3. The role of influential figures

Most of the senior officials are political appointees. Participants reported key aims of senior officials can often be traced back to their appointment. The reasons for appointment might include: a good standing within the party politics, demonstration of considerable benefit to the government in a previous post, ensuring religious or regional balance or their expertise in the specific field. There is an overriding expectation of being compliant with the central government and working to deliver the central government reform agenda. Understanding this context is important to understanding the decision-making drivers of senior officials.

Below the senior officials, there is a level of career civil servant, who are more often selected for the technical level of expertise and they have a lot of influence on technical decision-making. These officials are very important to

driving reform based on complex evidence. It was reported that quite a number come from academia — such as lecturers.

6.2. Research production and influence

This section has been compiled exclusively from the informal interviews undertaken. It first addresses which evidence is used by government policymakers, before considering implications for opportunities and strategies for evidence uptake in Tanzania.

It was noted by all the participants that research that is simply published will not have any impact on education system decision-making. The government uses evidence that is understood, relevant, and 'owned' by its officials. To ensure that evidence has an impact, it must 'become the government's research' — which they use within their own processes and functions to make changes. It is worth noting that government ministries and bodies do have research teams — however, participants noted that these teams play a role of approving research, rather than undertaking research.

To ensure research uptake, it is vital to ensure the relevant research is available at the right time to influence decisions. There are known cadences and process flows which need to be assessed in each specific policy area, to understand the entry points available. For example, the government often runs cross-ministry policies which are triggered by a feasibility study. The feasibility study (or similar project-triggering study) is an effective opportunity to arm the government officials with the data, evidence and research they need, to make the case for the specific project. By providing useful evidence to officials to present, it helps transfer the 'ownership' at least to some extent to the government. In the education system, these projects need to start within MoEST, who need to give approval, before work can move onto the other ministries and related bodies.

6.3. Opportunities and strategies for evidence uptake in Tanzania

It was clear across the interviews that there are many ways to promote evidence uptake, so that it appears to be relevant, understood and owned by the government. Here we have noted six prominent ways of doing so.

6.3.1. Research teams to partner with government when undertaking research

Partnering with the government to undertake research is a primary way of ensuring evidence uptake. It is a way of giving ownership to the government

at the beginning of a research cycle — and ensuring it isn't seen as research from 'outside of Tanzania'. It also ensures that the research is relevant — as it will link directly to the government demand. However for this to be effective, there needs to be some flexibility within the research to allow government officials to articulate the evidence gaps that they require filling. There also needs to be a realistic approach to timelines — so that the evidence can be communicated to policymakers in a timely way (possibly through a working paper, presentation of early findings or even via WhatsApp messages). Finally, this approach allows a long time frame for interaction with the government officials — to ensure that (often complex) ideas and evidence are well understood. This approach is especially important when looking to undertake at-scale research in government schools, as government officials will also be required to approve access for research. Further, given the previous central government policies which limited research publication, this type of partnership will shield the research from any future problems and issues. An example of setting up a partnership with the government is to set up a consultative committee at the start of the research — before specific research is identified.

6.3.2. Embed government officials within research teams

A possible next step from a partnership with the government is to include government officials within the research teams to undertake the research. This has notably been achieved within the RISE team, where the Director-General of TIE is embedded as part of the research team. It was reported that this approach gave the research team more understanding of government priorities and incentives, as well as contextual intelligence to enable both research and uptake.

6.3.3. Effective engagement with the bureaucrats who power the education system

Another key approach that was cited by multiple participants was effective and active engagement with all officials. Specifically ensuring that engagement is not just targeted at the senior officials. To undertake this engagement effectively it takes time and input to build and maintain relationships, being able to respond to requests promptly and 'pick up the phone to give officials the evidence they need, whether it is at the weekend, or with a very short deadline'. This type of engagement is not always common practice, especially within traditional academic research institutions — therefore a specific engagement strategy and monitoring may be required to ensure it is effective.

6.3.4. Framing research policy outputs in a useful way for change

Given the central control within government — linked all the way back to the President's Office — it is vital that research is framed in a way that is productive for officials. If research is narrow, it has the tendency to be overtly critical of government actions, without presenting suitable pathways and opportunities. This type of research is likely to be dismissed by the government as poor or incorrect research and will guarantee that the evidence is not used. It is not required to alter research findings but instead ensuring that research takes a broad systemic view — so that it can present a realistic mix of results. It means that when findings are communicated to the government this should be done with tact and understanding of the political system — presenting the successes and opportunities for change. It was also noted that sharing results with the government before any other stakeholders is vital so that the government are not 'blindsided' and are able to proactively manage change.

6.3.5. Develop strong relationships with donors to embed research

The donor community has a unique role within the landscape of evidence uptake. Major donors have a real opportunity to make research visible to important government officials, add weight or backing to evidence, and also fund changes linked to evidence. This evidence is used within the donor funding cycle — especially within the Sector Development Plan and the identification of DLIs. The education evidence which is commissioned or used by donors tends to be the evidence that is deemed important by the donor's local education specialist(s). Therefore to promote uptake by donors — researchers can use similar strategies to those which are used with the government — such as early partnership with particular donors or embedded staff (such as the World Bank embedded staff in the RISE Tanzania research programme). At a minimum, the research teams need to actively engage with the local donor education specialists, especially from the EP4R funding organisations, to ensure that research is also fed in through donor channels.

6.3.6. Consider using other channels to create change in the government — MPs and the public

Think tanks have used other channels to promote uptake of research — by galvanising a significant number of Members of Parliament to advocate for the evidence or publicising results through the media. This is a clear route to influencing the ministers and senior officials within the government, who have to take note of a groundswell of support for a particular piece of evidence. This

was noted as a particularly successful approach by one of the local think tanks — who had over 100 MPs attend a bespoke event to disseminate evidence. However, it should be noted that there is a balance that needs to be made with government partnership and working with MPs — as trying to overtly take both approaches may cause conflict. Researchers seemingly have to balance this approach with creating government partnerships. One researcher noted that "quiet conversations with government are more effective than public engagement".

6.4. Who produces research used by government policymakers?

More actors are detailed in the stakeholder analysis (Annex D), however, a summary of the main research used by the government is detailed here.

6.4.1. Longitudinal research programmes in partnership with government

These programmes were reported to have the highest impact within the education system. The most notable of these was reported to be the RISE programme. Other programmes were highlighted to be very impactful, such as World Bank reports, but often more linked to the wider funding available from the organisation than through broad uptake in the government. These research programmes tend to have a mix of researchers from international and local institutions.

6.4.2. Local research think tanks

These organisations (listed in Annex D) have a high public profile. It was reported that they are much more impactful around policy change than the local universities alone (however they often contract universities to undertake research). They use public channels and work through MPs, not necessarily through the government, but there are exceptions.

6.4.3. Local universities

These organisations tend to have limited uptake of evidence through published research. This was noted by one participant as being because they 'are more interested in the pursuit of knowledge than policy change', and therefore don't spend time lobbying or engaging the government. However it was noted there is a key exception to this, which is high profile senior academics within the universities with connections to the government. It was noted that the government really values this external input, but that they tend

to approach academics directly because when going through the universities the process can become politically difficult.

7. Emerging priorities and opportunities for collaboration

In this review, we have drawn upon a range of sources — including contextual statistics, policies, political economy analysis, and the existing research literature — to present an overview of the landscape of EdTech research in relation to school-level education in Tanzania. Although progress has been made in improving access to education, inequalities exist in relation to socio-economic lines, urban and rural contexts, and gender, for example (Section 2). Tanzania has an established and growing community around EdTech research (Section 4); there is potential for the EdTech Hub to work in partnership with the community, and promote further collaboration and knowledge sharing. As a result, we were able to draw upon a substantial body of existing research literature (Section 3) and explored mapping the literature on to the EdTech Hub's five focus areas (Section 5). It should be noted that most of the existing research literature did not map directly on to the focus areas; however, this research nonetheless provides findings that will be helpful for context, moving forwards.

Finally, we explored the influential actors and dynamics in relation to education and technology within the Tanzanian educational system through PEA (Section 6). A key thing to note from this analysis is the lack of direct school level engagement in decision-making around EdTech. It is vital to ensure that the voice of the user is reflected in products and services — so for EdTech to scale, it is important to look at ways of doing this either through more systematic user research or devolved decision-making power. Considering both the evidence gaps in existing research literature that emerged in Section 5, and the practicalities of the operating context outlined in Section 6, we have identified three areas as being potentially valuable focal points for the EdTech Hub and its work, moving forward.

7.1. Individualised and remote learning

There have been a number of promising personalised adaptive learning initiatives undertaken in Tanzania in recent years, the most prominent examples come from the Global Learning XPRIZE. This is reflected in a cluster of research papers, as discussed in relation to the first focus area - Technology to support personalised learning and teaching at the level of the student (Section 5.1) - which provided robust research evidence of their efficacy. However, there are questions around the sustainability of this type of initiative,

as they rely on assumed connectivity and hardware and are mostly donor funded.

There is an increasing demand in government to provide content to learners and the EdTech Hub has been working within Zanzibar to support the development of a Virtual Learning Environment. The onset of the Covid-19 pandemic prompted a significant boost, where a number of providers joined with the government to provide remote learning — including Ubongo Kids and Kasome — through a range of high- and low- tech delivery mechanisms such as TV, radio and online (↕Global Partnership for Education, 2020). Exploring the potential for principles of personalised adaptive learning to be applied through scalable, cost-effective media could be a useful area for further research and technical development. There is likely an opportunity for EdTech companies and organisations to work with the government to bring individualised learning into the government schools — however it will rely on companies being able to bring the price down enough for delivery at scale.

7.2. Technology-enabled continual TPD

TPD is an area where there is both a particular interest at the policy level and existing in-country research to build upon and extend. In Section 5.2, four key evidence gaps were identified, drawing upon the existing research literature.

The TIE has been given the mandate for TPD, and this is coupled with support for reform within MoEST. As the new five-year sector development strategy is being produced there is a real opening for the government to bring in aspects of digital technology as part of TPD, and to do so in an evidence-based way by building on the learning from effective technology-enabled TPD programmes in the region (↕Piper, et al., 2017). The TIE Director-General, Dr Aneth Komba, is a researcher in her own right and gives a key institutional link to undertaking reform in this area. Looking ahead, the research literature would suggest that involving teachers in co-design and collaborative approaches to TPD can enhance integration of technology use within their classroom practices.

7.3. EMIS and management products

There is a real acknowledgement across education actors of the need for reliable data for decision-making, accountability and transparency. This is reflected in the research literature associated with the third focus area (Section 5.3).

The political economy of decision-making regarding EMIS and education management of digital products has fewer direct stakeholders, compared to other areas. The EMIS and Management Products remit sits within the

President's Office, Regional Administration and Local Government (PO-RALG) and the key decision-makers are the Director of Education and Administration and the Director of ICT. This agenda fits into different central government agendas including digitalisation, reducing corruption and infrastructure. The PO-RALG has some very capable teams which have produced products such as the Online Teachers Employment Application System (OTEAS), The School Information System (SIS) and the Teachers Promotions System (↑Mtebe, 2020). Although there are capable digital teams, there is often difficulty in changing policy to allow the use of digital products and services, so ensuring buy-in across the institutions that influence specific policies is also vital.

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9. Annexes

9.1. Annex A: Country data

Table 1 collates data from varied sources in order to outline the operating context in relation to EdTech research, implementation and evaluation in Tanzania. Section 2 provides detail on the raw data listed in the Table. It must be noted that deriving a unified set of statistics to populate Table 1 brought certain challenges due to asymmetrical information. As such, the data presented draws on various data sources, using government data as far as possible, or, where appropriate, the most recent, robust data source.

Table 1. *Country overview.*

Population	Total population	In July 2020, the population was recorded to be 58,552,845.
	Rural population	66% of the total population, or 38,644,878 people.
Language	Tanzania is a multilingual country with Kiswahili — the official language — and English, spoken as lingua francas. Kiswahili is the language of instruction for pre-primary and primary levels. This changes to English for secondary and higher education.	
Literacy	In 2015, the literacy rate for those aged 15 years and older was 77.9%.	
Infrastructure and technology	Schools	In 2016, there were: ■ 16,857 pre-primary schools; 17,165 primary schools; and 10,065 secondary schools.
	Electricity	■ 33% of the total population have access to electricity. ■ In 2016, of 17,165 primary schools, 14.6% had no access to electricity, with 22.2% connected to the national grid. The remaining 63.2% of schools had access to some kind of power source (e.g., solar).
	Technology	■ In 2019, there were around 82.2 mobile cellular subscriptions per 100 people.[44] ■ In 2016, 4% of households had access to a personal computer. ■ As of March 2020, there were 37 television stations and 183 radio stations.

[44] For more information on mobile telephony subscriptions as of March 2020, see Table 4 of ↕Groeneveld & Taddese's (2020) country scan of Tanzania.

	Internet	In 2018, 25% of the population used the internet, while in 2019, 1.78 of every 100 people had a fixed broadband subscription.
	Secondary school ICT equipment	In 2016, there were: 60,451 desktop computers; 13,319 laptops; 6080 photocopiers; 8871 printers; 3510 projectors; 1711 radios; 6845 smartphones or tablets; and 5952 televisions.
Learners	School-age population by education level[45]	■ Pre-primary — 3,436,505 ■ Primary — 10,737,827 ■ Secondary — 7,298,998
	Primary students	■ In 2019, there were 10,605,430 students at a gross enrolment rate of 98.76%. ■ 2016 figures show that 37,034 primary students (of 8,639,202, or 0.43%) had special educational needs and / or disabilities (SEND). ■ In 2016, there were 389,840 “repeaters”, or learners who repeated a year, across all seven standards. ■ In 2015, there were 85,985 dropouts, with 95.6% of these dropping out due to truancy. ■ In 2020, 3.8% of children attended private primary schools.
	Primary to secondary transition	In 2018, the effective transition rate from primary to lower secondary was 71%, with 84.93% of children surviving to the last grade of primary education in 2018.
	Secondary students	■ In 2016, there were 1,806,955 secondary school students. ■ In 2016, the gross completion rate was 38.6%. ■ 2016 figures show that there were 7512 secondary SEND students (0.42%). ■ 2016 figures also show that 194,849 students were considered ‘vulnerable’, with 86.1% of these students coming from low-income households. ■ In 2015, there were 61,488 dropouts, with 93.2% of these dropping out due to truancy. ■ In 2016, there were 27,428 “repeaters”, with 89.6% of these attending government secondary schools. ■ In 2019, the gross enrolment rate was 32.04%.

[45] Note that there are discrepancies between the number of school-aged learners at each education level and the number of recorded learners at each education level where, for example, many secondary school-aged children attend primary school.

		■ In 2020, 16.9% of children attended private junior secondary schools. ■ In 2020, 32% of children attended private senior secondary schools.
	Out-of-school children	■ In 2019, 1,434,649 out-of-school children (OOSC) were recorded in total. ■ In 2016, 3,363,461 out-of-school adolescents were recorded.
Teachers	Primary teachers	In 2018, there were 206,829 teachers, a 2016 figure shows that 99.2% of primary teachers were trained.
	Primary pupil:teacher ratio	In 2018, the pupil:teacher ratio was 51:1.
	Secondary teachers	In 2019, 108,596 secondary teachers were recorded, while in 2016, 106,904 secondary teachers were qualified.
	Secondary pupil:teacher ratio	In 2018, the pupil:teacher ratio was 21:1.
Systems	Policies and frameworks	■ The ↕Ministry of Education, Science and Technology's (2018) Education Sector Development Plans (EDSPs) lay out educational policies and strategic objectives in 5-year or 10-year periods. ■ The ↕Ministry of Communications and Transport's (2003) National ICT Policy; ■ The↕Ministry of Works, Transport and Communication's (2016) Implementation Strategy for the National ICT Policy; ■ The↕Ministry of Education and Vocational Training (2007) Policy for Basic Education. ■ The ↕Ministry of Education and Vocational Training & UNESCO Office Dar es Salaam's (2015) ICT competency standards for teachers in Tanzania.
	Expenditure on education (in aggregate)	In 2019 government expenditure as a percentage of Gross Domestic Product (GDP) was 3.7% or 20.6% of total government expenditure.
	Expenditure on education per student (in purchasing power parity (PPP$))	In 2014, the government spent $209 per primary student compared to $328.1 of initial government spending per secondary student.

Source: Adapted from ↑Central Intelligence Agency (2020); ↑Groeneveld & Taddese (2020); ↑President's Office, Regional Administration and Local Government (2016); ↑UNESCO Institute for Statistics (2020); ↑Unterhalter, et al. (2020); ↑World Bank Development Indicators (2020); (↑World Bank, 2021).

9.2. Annex B: EdTech companies

EdTech companies active in Tanzania. The main source here is the EdTech Hub companies database, including company name, website, and organisation purpose: https://airtable.com/shrWkzpnLTpjP2ip8/tblUhRGOHZgazHHY5

Mtabe (www.mtabeapp.com)

Providing offline e-learning to secondary school students in Africa.

OneMinute Limited (www.oneminute.co.tz)

To offer low cost and yet innovative data management solutions to individuals, companies and institutions to help them achieve effective decision-making.

The Launchpad Tanzania (www.thelaunchpad.or.tz)

21st Century Skills for Employability and Entrepreneurship; Educational reforms for all phases; Equitable Inclusion.

HakiElimu (www.hakielimu.or.tz/)

As an expert in education, policy analysis and advocacy and with almost 20 years' experience, HakiElimu is one of the leading national organisations in Tanzania contributing to tackling the challenges within the education sector. Our vision is for an open, just and democratic Tanzania where all people enjoy the right to education that promotes equity, creativity and critical thinking. Our mission is to enable people to transform education, in and out of schools; influence policy making and effective implementation; stimulate imaginative public dialogue and social change; conduct research, policy analysis and advocacy; and collaborate with partners to advance participation, accountability, transparency and social justice.

Ubongo (www.ubongo.org)

At Ubongo we leverage the power of entertainment, the reach of mass media, and the connectivity of mobile devices, to deliver effective, localised learning to African families at low cost and massive scale.

Shule Direct (www.shuledirect.org)

Shule Direct's goal is to provide local and accessible digital educational content for young learners across Tanzania and Africa to improve their learning outcomes. We are working with qualified teachers to create digitised learning notes, tutorials, quizzes and multimedia content and developing technological solutions to deliver comprehensive curriculums on web and mobile solutions. Shule Direct delivers web and mobile platforms as supplementary and alternative solutions to the knowledge and information divide for Secondary School students. We offer the entire Secondary School curriculum, Life Skills and Financial Education content on a web platform, an application for android and iOS, an SMS platform and an offline Learning Management System for schools. Initial early effort in content build and structuring of our digital content repository has enabled us to use it for current platforms and into the future for a variety of different platforms and applications without recreating our content. Students and Teachers can access our online platforms on any mobile device and license our offline learning management system developed exclusively for computer labs in schools.

Sigma School
(https://play.google.com/store/apps/details?id=com.olbongo.learnit)

To digitalise and democratise Higher Learning process, to help close skills gap and unemployment problem among African youth in a way that prepares them for the future of work and secure their place in a changing world.

ElimuTanzania (www.elimutanzania.com)

To use tech penetration to offer educational resources for preparation of examinations to the underprivileged for free.

World Possible Tanzania (www.worldpossible.org)

To bridge the offline learners to the World's knowledge

Smartcore Enterprise Limited (www.smartcore.co.tz)

Smartcore is a social enterprise and a digital learning content development agency with a primary focus to transform the learning experience and improve academic performance to 12 Million East African secondary school learners, by providing them with local relevant & interactive digital learning content.

SmartClass Company Limited (www.smartclass-tz.com)

SmartClass matches students to qualified and affordable tutors based on their learning needs. Students can take their classes online or offline.

Elimutube (www.elimutube.co.tz)

Elimutube is an EdTech company created to eradicate the problems of education in Tanzania. We find the best teachers in Tanzania with exceptional performances in the subjects they teach, publish their notes and also create high-quality video tutorials of them teaching.

Kasome (https://kasome.com/)

Kasome is a video library platform covering the secondary school curriculum using the selected teachers in Tanzania. It enhances the school experience to students, enabling them to refresh on topics outside of the school day.

9.3. Annex C: EdTech research literature characteristics

Figure 10. *Distribution of articles in the literature review, according to year of publication.*

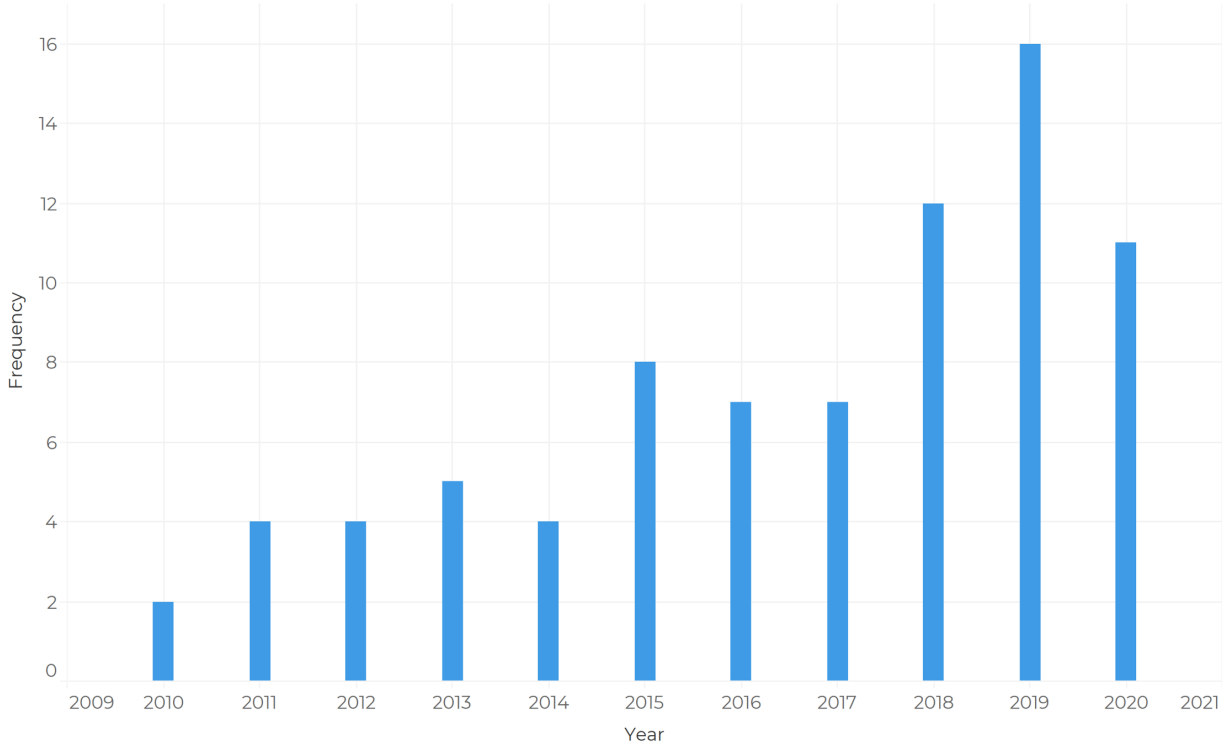

Table 2. *Frequency of publication types within the collection of articles included in the literature review.*

Type	Frequency
Book or book chapter	5
Conference paper	27
Journal paper	42
Report	5
Thesis	1

Conferences within the literature review:

- AAAI Conference on Artificial Intelligence [2]
- Computer Supported Collaborative Learning (CSCL)
- Computer-Human Interaction
- European Conference on Innovation and Entrepreneurship (ECIE)
- Global Humanitarian Technology Conference (GHTC)
- ICT4D
- IEEE Africon [2]
- Information Communications Technology and Society (ICTAS)
- International Conference for Internet Technology and Secured Transactions (ICITST)
- International Conference Mobile Learning
- International Conference of the Learning Sciences
- International Conference on Advanced Learning Technologies
- International Conference on Artificial Intelligence in Education (AIED)
- International Conference on Computers in Education

- International Conference on Teaching and Learning in Computing and Engineering
- International Conference on Technology for Education
- IST-Africa [3]
- Learning@Scale
- Pan African International Conference on Information Science, Computing and Telecommunications (PACT) [2]
- SIGCAS Conference on Computing and Sustainable Societies [2]

Journals within the literature review:

- Australasian Journal of Educational Technology
- British Journal of Educational Technology
- Compare: A Journal of Comparative and International Education
- Education and Information Technologies [7]
- Educational Technology & Society
- Educational Technology Research and Development
- Information Technology for Development
- International Journal of Advanced Engineering Research and Science (IJAERS)
- International Journal of Education and Development using Information and Communication Technology (IJEDICT) [11]
- International Journal of Education and Research
- International Journal of Educational and Pedagogical Sciences
- International Journal of Educational Policy Research and Review
- International Review of Research in Open and Distributed Learning
- Journal of Applied Developmental Psychology
- Journal of Education and Practice
- Journal of Learning for Development (JL4D) [6]
- Journal of Science Teacher Education

- Knowledge Management & E-Learning: An International Journal
- The African Journal of Information Systems [2]
- The African Symposium: An online journal of the African Educational Research Network

Table 3. *Frequency of institutional affiliation of Tanzania-based authors within the collection of articles included in the literature review.*

Type	Frequency
University of Dar es Salaam	17
Nelson Mandela African Institute of Science and Technology	9
University of Dodoma	5
University of Arusha	2
Dar es Salaam Institute of Technology	2
Sebastian Kolowa Memorial University	2
St Rock College of Early Education	2
Human Development Innovation Fund	1
Ilala Municipal Council	1
Kaliua District Council	1
Muslim University of Morogoro	1
Sokoine University of Agriculture	1
St Augustine University	1
Tanzania Institute of Education	1
TANZICT project	1

Tumaini University	1
UNICEF	1

Table 4. *Categorisation of articles included in the literature review, according to the three main EdTech Hub research themes. Note that some articles spanned multiple themes.*

Theme	Frequency
Learners	40
Teachers	35
Systems	19

Table 5. *Categorisation of research literature articles according to the 'study area' typology in the RLI.*

Overall theme	Study area	Frequency
Learners	Refugees and migrants	1
	Low-level foundational skills	14
	Gender and education	0
	Special education needs and disabilities (SEND)	2
	Minority groups	0
	Out-of-school populations	3
Educators	Parents and caregivers	2
	School administrators and senior leadership team	0
	Trainee teachers	1

	Teaching assistants	0
	Support and community workers	0
	Teacher trainers	0
	Teachers	6
	Teacher education (pre-service and in-service)	10
	Pedagogy	6
Education systems	Access	3
	Equity	1
	Assessment	1
	Accountability	1
	Governance	1
	Monitoring and evaluation	0
	Education financing	1
	Quality	3
	System readiness	8
	Curriculum and educational content	8
	Educational data	3

Note that (i) some papers were assigned to two categories, and (ii) some articles did not sit within any categories within this typology. Additional categories included: 'tech design and adoption' (29), 'intelligent tutoring

systems' (two), 'learner behaviour' (two), 'emergency responses', 'field testing', 'infrastructure', 'OER', 'scaling', and 'sustainability' (one each).

Information about **research funding** was absent from the majority of articles (56). The following funders were explicitly acknowledged in papers (number in parentheses indicates the number of papers; papers could have multiple sources of funding):

- Abdul Latif Jameel Poverty Action Lab (J-PAL) (1)
- Academy of Finland (7)
- Bill and Melinda Gates Foundation (BMGF) (1)
- Department for International Development (DFID) (2)
- Dow Chemical (1)
- Enuma Inc. (2)
- Fulbright Foundation (1)
- Harvard Business School (1)
- Harvard Kennedy School (1)
- IDRC (1)
- International Growth Centre (IGC) (1)
- International Youth Foundation (1)
- Jacobs Foundation (1)
- Korean Government (MSIT) (1)
- Korean International Cooperation Agency (KOICA) (2)
- Lenovo (1)
- MasterCard Foundation (1)
- Michigan State University (MSU) (1)
- Miller Center for Social Entrepreneurship (1)
- National Science Foundation (NSF) (1)
- Nelson Mandela African Institution of Science and Technology (NM-AIST) (1)

- Nokia Corporation (1)
- Nokia Institute for Technology (INdT) (1)
- Norwegian Pre- and Post-Primary Education Trust Fund (NPEF) (1)
- Pearson Foundation (1)
- Tanzania Education Trust (1)
- The EdTech Hub (1)
- The Multi-Donor Education and Skills Fund (MESF) (1)
- U.S. State Department (1)
- UKAID Challenge Fund (1)
- UNICEF (1)
- USAID (1)
- Vodacom Foundation (1)
- Wolfson Research Institute for Health and Wellbeing (1)
- World Bank (1)
- XPRIZE (1 noted explicitly as funder, although several papers from associated projects)

9.4. Annex D: Political economy stakeholder analysis

Table 6. *Political economy stakeholder analysis.*

Organisation	Type of Organisation	Produces or uses research?	Description
President's Office	Government	Uses research	President Magufuli came into power in 2015 and was re-elected in 2020 for a further 5-year term, before his death in March 2021. Magufuli had a no-nonsense central style of government — popularly termed as the 'Bulldozer' (↑UNICEF, 2017b). The president's office has a significant amount of power, which is wielded in relation to the education sector — as detailed in the section on decision-making. Opportunities to influence with research are limited, given the difficulty to get direct access to the President. It is unclear how the president's role will change with President Samia Suluhu Hassan coming into office.

Ministry of Education Science and Technology (MoEST)	Government	Uses research	MoEST is "the most important policymaker" in the education system (↑Quak, 2020). It is charged with policy creation, oversight, and monitoring — across the education sector. It also has a key role in interfacing with the Ministry of Finance and directing budgets. Within MoEST a lot of the decision-making power sits centrally with the Permanent Secretary (PS), who approves major policy decisions. Currently, the PS is Dr Leonard Akwipapo and looks to remain the same for the indefinite future, given his reinstatement following the election transitions. There are capable civil servants within MoEST who are dedicated to improving the education system. However, participants reported the incredibly high workloads of senior officials, which reduces the ability to deliver.
PO-RALG	Government	Uses research	PO-RALG has responsibilities across all sectors — with education just a segment. The main decision-making within education falls to the Deputy Permanent Secretary, Gerald Mweli, and the relevant directors such as Director of ICT and Director of Education and Administration. PO-RALG is responsible for supervising the day-to-day provision of educational services. This entails the implementation of policies, coordination, and monitoring. Their remit includes important functions like staff/teacher management and information systems and supporting/facilitating LGAs to deliver. PO-RALG has effective digital teams who have delivered digital products to the ministry such as the Online Teachers Employment Application System (OTEAS), The School Information System (SIS) and the Teachers Promotions System (↑Mtebe, 2020).
Other Government Bodies	Government	Uses research	The LGA is a significant delivery arm of the education system with key roles at the ward and district level. Although it is charged with delivery (and the decisions within delivery), it is not charged with policy or financial decision-making. So although the LGA is a fundamental part of the success of initiatives, it isn't a key decision-maker. If the LGA actors do not want to deliver or are unable to deliver a policy, it will likely fail. However, they are not necessarily part of the key decision-making for the policies or accompanying finance. The Tanzania Institute for Education (TIE) is tasked with curriculum design, development, and implementation. It is separate from MoEST, but its budgets are decided within MoEST. TIE will likely play a significant role in EdTech reform, given that it has the remit to oversee provision of digital content and Teacher Professional Development. The current DG, Dr Aneth Komba, has a strong background to champion evidence-based reform using technology, having worked with the RISE programme.

			National Examination Council of Tanzania (NECTA) is tasked with educational assessment. There is support within NECTA to introduce reform around digital learning assessment. Given the increasing numbers of students being assessed, this may be a useful efficiency saving. However this thinking is at an early stage — and the approach to full country assessments at various points is contentious in terms of efficiency. The Ministry of Finance decides budgets each year with MoEST and plays a crucial role in budget settlement. However, the input to decision-making regarding education remains at a high level and centred around budgeting decisions.
Education Sector bodies	Education sector bodies	Uses research	Education sector bodies include the Teachers Union, School Management Committees, and School Boards. Broadly, these groups do not have a wide influence when it comes to decision-making. Therefore there is a real need that digital reform brings these voices into product or service development because they are key actors in ensuring the success of a reform.
Local Think Tanks and Consultants	NGOs / CSOs / Individuals	Produces research	There are a number of local research think tanks which have a loud and public voice linked to education in Tanzania. They include Uwezo, HakiElimu, REPOA, and Economic and Social Research Foundation. They are registered as CSO or NGOs. They have undertaken some significant research such as the UWEZO biannual report, which gives a clear view of the learning outcomes in the country. These organisations do achieve uptake of evidence, often through public campaigns or through influencing MPs. Working with these organisations to ensure evidence uptake would be a useful 'extra avenue' alongside government influencing.
Local Universities	Universities	Produces research	Local universities produce a significant amount of EdTech research, as demonstrated within the literature review. It was noted across participants that universities tend to be 'producers of knowledge' rather than advocates for policy change — and therefore the influence on policy outcomes seems to be minimal. However, the same individuals within the organisation often are more powerful, but provide expertise directly to the government rather than through universities. Well-respected Professors have the opportunity to directly influence the government, in a way that most researchers (especially international researchers) are unable to.

International research initiatives	Universities / Companies / Consultants	Produces research	There are numerous international research initiatives and their efficacy is variable. The most important research programme in the Education sector (cited by most participants) was the RISE Programme, which appears to be unique in its longitudinal broad systems lens — with sustained and long term engagement with government and donors. Participants noted that international consultants tend to be ineffective if they are not part of a local team who can maintain the relationships to facilitate uptake.
Donors / DPGs	Donor Organisation	Fund and use research	Donors play a key role in the education system in using and finding research. It was reported that the major donors in Tanzania are: The World Bank, FCDO, SIDA, GPE, USAID and KOICA. The donors promote alignment through the Donor Partner Group (DPG) for Education, which is chaired by MoEST. EdTech is also covered within the DPG for Science, Technology and Innovation (ST&I), which is chaired between MoEST and COSTECH. The primary donor influence on the education system is through funding and the donor funding cycle — detailed in the section on drivers of reform.
Private sector EdTech providers	Private Sector	Fund and use research	Within Tanzania, there is a vibrant and active EdTech private sector, with many SME's in EdTech. Examples are: Ubongo, Mtabe, Shule Direct and Kasome. However, given the central structure of the decision-making in the education system, there is little opportunity to provide services to the government, as the government makes decisions at scale and there have not been solutions that can scale within the government budgets. Therefore most companies make revenue targeting users directly or by targeting private schools. The opportunity for influencing government is often minimal.