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Relevance of Digital Technologies in Scaling Education Innovations: The Case of Tanzania

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Abstract

This study explores the relevance of digital technologies such as apps, learning platforms, online collaboration tools, delivery systems (internet, websites, mobile) or a combination of these in scaling education innovations. An innovation is a new or improved product (good or service), process, or method in business practices. In education, innovations are observed in curriculum, teaching methods, institutional structures, and educational processes (to mention a few). Studies exploring the relevance of digital technologies in scaling education innovations are limited, making the study of interest to explore. Using two education innovations that successfully passed the proof of concept, the study assesses the relevance of technology along the five trajectories of scaling (depth, breath, spread, ownership and problem definition). Study findings establish that digital technologies, particularly learning management systems, mobile apps, WhatsApp and web-conferencing tools (particularly Google meet and Zoom) as applied in these innovations are relevant across all the scaling trajectories. Study findings contribute to the broader theme of scaling education innovation relevant for addressing sustainable development goal 4, of improving access to quality education. Further research regarding the scaling of existing education innovation through partnerships needs to be explored.

Keywords: *scaling, digital technologies, education innovations*

INTRODUCTION

Technology has been integrated in almost all sectors of the economy and has been applied in various education innovations. An innovation is a new or improved product (good or service), process, or method in business practices, that if executed produces results particularly significant positive change(s) to the lives of the beneficiaries. In education, innovations can be systemic and may include new theories, practices, pedagogies, processes (Thomas, Bodilly, Galegher and Kerri, 2004; Findikoglu & Ilhan, 2016; Serdyukov, 2017), as well as institutional structures and programmes (Mykhailyshyn et al., 2018), to mention a few. According to OECD (2016), the education sector is comparably more innovative in some ways compared to other sectors, with most countries having innovations in teaching methods. Besides improving the quality of teaching and learning across settings, education innovations enhance equity of learning opportunities and equality in learning outcomes (OECD, 2016). On the quality of learning, education innovations increase; a) productivity where

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more outcomes (knowledge, skills, competencies, individual behaviour and attitudes) are achieved with less effort and; b) efficiency, the balance between resources and time invested to obtain results (OECD, 2016; Serdyukov (2017). Indeed, educational technologies such as websites, web-conferencing tools, learning management systems and mobile apps have transformed the way innovations are piloted, scaled up and preserved (Van Ouytsel et al., 2014). The transformations are evidenced in the growth of open education resources (OERs) and massive open online courses (MOOCS) (OECD, 2016) making it possible for international collaborations while at the same overcoming geographical and cultural learning barriers. Teachers are also tailoring their approaches to enable learning across different time zones.

Besides diverse technological advancements across sectors, improvements in learning outcomes in terms of students' performance as well as enhanced equality and equity on the provision of quality education are not that significant (OECD, 2016; Zennouche, Zhang & Wang, 2014). On the one hand, teachers as change agents are not involved in the design of the innovations (Vvob, 2021; OECD, 2016; Looi & The, 2015). On the other hand, education innovations that have passed the proof of concept are not scaled up to benefit the broader population due to limited financial resources which affect their sustainability. Indeed, most education innovations are projects and/or programme interventions and hence limited by short term funding that does not allow for scaling up (Teh & Looi, 2015). Scaling refers to the implementation and dissemination of innovative interventions (successful policies, programs, project interventions or designs) that have passed the proof of concept to enable for a wider outreach (Hartmann & Linn, 2008; Ostlin, 2016).

Coburn (2003), Clark & Dede (2009) and Cooley (2016) provides dimensions for visualizing scaling, five of which are adopted for this study; spread (extending the innovation to new geographic locations and new categories of clients); breadth of coverage (extending the innovation to more people in currently served categories and localities); depth of services (extending additional services to current clients); ownership (decentralizing the ownership of the innovation and/or change the innovation and share to other potential adopters); and problem definition (extending current methods to new problems). While digital technologies facilitate coordination among different actors particularly the initiators (founders of the innovation), enablers (supporting system), competitors (other providers of similar related innovation), and the impacted (the beneficiaries) along the scaling system; (Price-Kelly, van Haeren and McLean, 2020), studies exploring the relevance of digital technologies in scaling education innovations along the dimensions are limited, views also shared by Serdyukov (2017) and OECD (2016). According to Cooley (2021) scaling up an intervention requires "drivers" (particularly champions, incentives, technology, market and/or community) to push the scaling process, "enabling conditions" (fiscal, institutional and political as platforms and structures to support the process) and partnerships (collaborations among different actors, institutions, researchers, NGOs) whose presence or absence can significantly spearhead and/or stifle the scaling process.

This study explores the scaling dimensions of two evolving education innovations considering the Tanzanian context to establish how they apply digital technologies along the process. The study will address the question; how do innovations apply

digital technologies to scale up along the five dimensions? The Tanzania education system comprises 2-7-4-2-3+ meaning two years of pre-primary, with one year being compulsory, seven years of primary education, four years of low-level (ordinary) secondary education, two years of high-level secondary education and three-plus years of university education. In this regard, exploring the role of technology as a driver and an instrument towards successful scaling of education innovations is relevant with the findings offering further guidance along the process among different actors, views also supported by Serdyukov (2017).

REVIEW ON SCALING FRAMEWORKS

The literature shows that it is challenging to adapt and scale up successful education innovations to a variety of settings effectively and sustainably (Moore, 1999; Dede, Honan & Peters, 2005; OECD, 2016; Vvob, 2021). According to Vvob (2021), the challenges emanate from the involvement of a high number of decision-makers along the scaling process, with teachers, the centrality to the process being not well integrated, views also shared by OECD (2016) and Looi & Teh (2015). Additionally, the way the innovations are designed, piloted and supported makes it challenging for the government systems (rules and regulations) to adopt and fit them within existing resources, institutional structures and incentives. Indeed, the government systems become adamant to change, especially when additional resources are called to scale up successful innovations (Fuad, Musa and Yusof, 2020). There also exist contextual factors that affect the desirability, practicality, and effectiveness of potential education interventions/innovations in the classroom setting such as teacher's ability to own and practice the innovation in terms of content preparation, pedagogical styles and classroom culture with these contextual factors making it difficult to adopt innovations in new settings (Dede, 2016; Schneider & McDonald, 2007).

Research on the scaling of education innovations further focused on frameworks that offer guidance along designing intervention for scaling (Coburn, 2003; Clark & Dede, 2009; Cooley, 2016; 2021; Price-Kelly, van Haeren and McLean, 2020; Kohl, 2021), the scaling process (Petersen and Smith, 2011) and core functions meant to support the scaling process (Crouch and DeStefano, 2017). Petersen and Smith (2011) view scaling as a sequential process comprising four stages; research, development, evaluation and scaling with each needing separate funding approaches. Crouch and DeStefano (2017) identified three core functions in terms of capacities that education systems should focus on to support large-scale educational innovations, particularly (1) setting and communicating expectations among the innovation actors, (2) monitoring and guaranteeing accountability for meeting those expectations, and (3) intervening to ensure the support needed to assist students and schools that are struggling.

Price-Kelly, van Haeren and McLean (2020) developed four guiding principles for scaling an impact which include: justification, coordination, dynamic evaluation and optimal scale. The justification principle places focus on the need for scientific evidence prior to scaling of an innovation to understand its feasibility including the relevance of the innovation considering the values of beneficiaries. Coordination involves the act of supervising and managing the activities of different actors along the scaling process. Dynamic evaluation

includes conducting on a continuous basis assessment to measure progress and learn best practices along the scaling process. The three principles are key to realize optimal scale of the innovation, which is measured on the impact the innovation has on the magnitude (in terms of size, quality, number beneficiaries, and its importance as judged by stakeholders), variety (health, economic and environmental impacts of the innovation), sustainability (long lasting impacts of the innovation; and equity (benefits and/or harm the innovation brings to different sub-groups based on gender, religion, or class).

There also exist crosscutting issues affecting scaling of education innovations, which include among others the relevance of systems, particularly the decision and system capacity of governments to adopt the innovation, demand-driven innovations and digital technologies (Kohl, 2021). Accordingly, the pillars of the 21st century learning are digital technological innovations ranging from web-enabled information storage and retrieval systems such as MOOCs, wikis, blogs; digital resources, eTutoring, social networking and mobile learning to mention a few (Holmes et al. 2018; Lynch, 2017; Sijing and Lan, 2018). The fourth industrial revolution also integrates artificial intelligence in education as evidenced on the development of customized learning experiences and assessment-based learning outcomes (Becker, Cummins, Davis, Freeman, Giesinger and Ananthanarayanan, 2017; Holmes, Bialik, & Fadel, 2019). According to Groth, Nitzberg & Zehr (2019) and UNESCO (2019), these resources are embedded in infrastructure such as learning management systems and are designed innovatively building on best practices using quality international and national standards.

Building on the frameworks, digital technologies are relevant towards the scaling of education innovations as they enable for realization of four levels of technology integration. According to Puentedura (2013; 2014); the levels also abbreviated as SAMR framework include a) Substitution, the lowest level of technology integration where technology acts as a direct tool. In this regard, curriculum content can be added in a learning management system to substitute a reference list for students without further interaction along the learning process; b) Augmentation, where technology acts as a direct substitute tool with functional improvement such as the use of microsoft word for checking grammar; c) Modification, where technology enables the realization of learning objectives through sharing of resources via google docs, blogs and emails enabling for online collaboration and peer learning among learners; and d) Redefinition, the advanced level of integration where technology allows for creation of new tasks that without it, they could not have been possible to be realized. Typical examples include creation of Open Education Resources (OERs) and online courses that can be shared beyond the physical classrooms. According to McKnight et al (2016), content creation enables the development of the four Cs, critical thinking, creativity, collaboration and communication to students as key skills in the 21st century.

Related Works

Studies linking technology and education innovations have focused on conceptualization of education innovations as products, processes, strategies and approaches that significantly improve classroom practices (see OECD/Eurostat, 2005; OECD, 2016; Bocconi, Kampylis, and Punie, 2012; Pinasu, 2014; Fuad, Musa

& Yusof, 2020). Accordingly, three types of education innovations are observed (see OECD/Eurostat (2005); a) products or services innovations (example new syllabuses, textbooks or educational resources); b) innovations in technology, tools or instruments (new processes for delivering services such as use of ICT in e-learning services, new learning management systems, new online courses, or new pedagogic tools); and c) innovations in knowledge or methods (such as new pedagogies, new administrative management systems for admissions or other formalities, or the use of ICT to communicate with students and parents). Other studies have focused on the types of educational technologies (see Popescu and Crenicean, 2012; Mykhailyshyn et al., 2018), characteristics of education innovations (Wai, 2017), and technology as a driver for innovation (Serdyukov, 2017; OECD; 2016; Ng, 2009). According to Popescu and Crenicean (2012), innovations in education can be a) technical; meaning the use new technologies such as Zoom, learning management systems or mobiles in education to deliver learning, b) conceptual; that is the introduction of new programmes, courses, methodology; and c) relational; meaning bringing better ways of communication interaction among different educational stakeholders within and outside institutions.

Serdyukov (2017) conducted a systematic review regarding education innovations in the US and the related hurdles. The study recommended the need to increase the scale and transformation rate of innovations in the education system using technology among others, given the dearth of research in this direction. A systematic review by Panirsilvam (2017) further established; a) macro factors particularly communicating the scaling strategy, institutional structures (a hybrid approach involving both top-down and bottom-up; and supporting structures (continuous professional development and capacity building to the adopters of the innovation) and b) micro factors (attitude towards the innovation especially among the educators and teachers) to be key towards successful scaling of of education innovations with most innovations having positive students' outcomes as measured based on their academic performance. Zennouche, Zhang & Wang, (2014) further found out that, a) individual factors particularly personality, motivation and cognition ability; b) group level factors (structure, climate, leadership and task characteristics); and c) organizational factors particularly structure, culture, strategy and resources to have influence on fostering or hindering innovations regardless of the context.

The studies came to a conclusion that education innovations are key towards the realization of SDG 4 if they are successfully scaled up. Indeed, education innovations that integrate digital technologies facilitate the teaching and learning processes by providing platforms for improved content presentation (Sedukyov, 2017; OECD, 2016). They also strengthen collaboration and communication among stakeholders (Popescu and Crenicean (2012). Education technologies also enable for expansion of education products and services geographically across different levels of education with this aligning to the "spread" dimension of scaling (Mykhailyshyn et al., 2018; OECD, 2016). Education innovations further enhance individualized learning (Ng, 2009; Smith, 2009) and brings about improved education results (Fuad, Musa & Yusof, 2020) measured at the a) output level considering the number of beneficiaries benefiting from an innovation, example the number of teachers benefiting from a continuous professional development training; b) outcome level which considers

intermediate results particularly when the direct beneficiaries put into practice the knowledge and skills emanating from their direct participation in the innovation activities. For example teachers can train other colleagues about a new improved pedagogy after attending a capacity building training; and c) impact level, also termed as long-term results where all the trained teachers (direct and indirect) change their practice by applying the new improved pedagogy, with changes observed on the learners improved attitude towards learning, improved skills and improved academic performance) as a result of the innovation.

METHOD

Research Design, Study population and Sampling

The study was qualitative and used a case study design. Case study approaches enable in-depth description of a particular case or multiple cases where a researcher gathers detailed data from a small sample with the information enriching the understanding of the investigation at hand (Denzin & Lincoln, 2005; Creswell, 2007; Yin, 2014). The newness and limited awareness among the stakeholders regarding the concept of scaling and the application of technology in the process has also made it relevant to use qualitative approach in this study.

The target population for the study included education innovations that have had impact and have existed in the Tanzanian context over the past ten years. According to Cooley (2016) and Kohl (2021), successful scaling up of a pilot intervention to national application requires multiple projects over a period of 15 years. It was however not possible to get two innovations that existed over the past 15 years, due to sustainability aspects, except for one this study. Likewise, data available to establish the number of education innovations has been a challenge in education systems (Foray & Raffo, 2014). The study therefore selected two education innovations that have been piloted from 2003 (for case 1) and 2012 (for case 2) and have had impact on policy reforms as established from their evaluation studies (HELVETAS, 2022; Shule Direct, 2018). Four participants (2 males and 2 females) were selected to provide data for the study with their selection based on their engagement in the design and piloting of the innovations over an extensive period of time. It was also important to purposively select the innovations that demonstrate the five scaling dimensions (Coburn, 2003; Clark & Dede, 2009 and Cooley, 2016). The selected innovations as well demonstrate diversity on innovations types ranging from improved pedagogies, teacher professional development component, as well as delivery of resources using technology including new assessment forms (OECD/Eurostat, 2005; OECD, 2016).

Data Collection Tools, Data Analysis and Ethical Permissions

In-depth interviews were conducted with the questions aligning to the scaling dimensions of spread, depth, breadth, ownership and problem definition. To establish the validity of the data, documentary review (evaluation reports from the innovations) and observations of aspects demonstrating the impact of the innovations was done. To triangulate the findings, it was important to interview the beneficiaries of the innovations where two participants (equal number of male and female) from each

were conveniently selected for the purpose.

The qualitative data collected were recorded with participants' consent. The audio clips were transcribed verbatim, coded and analysed using MAXQDA 2018, a software for analysing qualitative data. The analysis was based on the scaling dimensions as coding themes with the same guiding the presentation of the findings. Participants' voices are also added to bring rigour to the findings. The study further adhered to the University research clearance committee formalities and ethical standards. Likewise, the data has been used in line with the intended study purpose (Cohen, Manion & Marrison, 2011).

FINDINGS

Study innovations and their features

Case 1: School In-service Teacher Training (SITT)

SITT is a practice-based teacher mentorship and support approach that involves training mentor teachers to coach and mentor fellow teachers through peer learning exchange, model lessons and team teaching. SITT was first piloted in select districts in Tanzania in 2003 and has since gained momentum across Tanzania's primary schools. Since its establishment, a total of 532 from 19 districts in 7 out of 31 regions of Tanzania have benefited from the SITT model, with 507 schools applying the intensive SITT approach (where schools are reached through training organized by national facilitators) and 25 schools the extensive approach (where teachers/schools are reached by Teacher Colleges. Evaluation reports reflect improved academic performance of the schools benefiting from the SITT model (See Table 1). The primary SITT model through funding from the International Development Research Centre is now being adapted and scale up to secondary schools in Tanzania, Kenya and Zambia with the objective of supporting government efforts to implement well-functioning inclusive school-based in-service teacher training programs that are effective in improving the quality of teaching, empower students and enhance the quality of basic education.

Table 1. Improved academic performance in SITT schools

% of pupils that passed with an A or B grade in 56 SITT schools			
	Math	Science	English
2016	13%	39%	16%
2017	19%	31%	15%
2018	44%	43%	29%
% of pupils that passed with an A or B grade, average for all schools in the 3 regions			
2016	14%	32%	16%
2017	19%	28%	14%
2018	37%	35%	28%

Source: Annual Project Review Meeting Report from District Councils, 2018)

Case 2: Shule Direct

Shule Direct (www.shuledirect.co.tz) is Tanzania's premier and leading digital learning platform that aims to improve learning outcomes across Tanzania and in the region. Its mission is to leverage existing technologies to improve access to qualified, local and relevant learning resources that aligns to the national ordinary secondary level curriculum for all young learners in Tanzania at a low cost. Shule Direct also has its digital Teachers' Resource Center as an interactive and responsive learning platform for continuous professional development. Shule Direct works with a number of key education and qualified teachers to create digitized learning notes, tutorials, quizzes and multimedia content and develop technological solutions to deliver comprehensive secondary school curriculum and extracurricular content to learners through any accessible technological device. Since its operationalization in 2013, over 3 million young learners have managed to access the platform and over 50,000 teachers have been registered benefiting from the platform resources. In response to the COVID-19 pandemic, Shule Direct partnered with two of the leading Mobile Network Operators in Tanzania to zero-rate its platforms, thus removing the data cost barrier to their users.

Study innovations along the scaling framework dimensions

Spread

All innovations extended to new geographic locations and have also added new categories of clients aligning to the spread dimension of scaling.

Case 1 innovation for example targets primary school teachers, teacher college tutors, Quality Assessors, Ward Education officers and District Education officers as direct beneficiaries and pupils and student-teachers are indirect beneficiaries.

"Last year [2021], we managed to partner with three universities and scaled up the innovation to secondary level currently piloted in Tanzania, Kenya and Zambia expanding its coverage beyond the country and the education level..., 105 secondary schools are benefitting from the innovation..., For the primary SITT, this year [2022], we have added more schools in 9 districts making a total of primary schools benefitting from it to be 588..., (Case 1_45).

Case 2 innovation started with three secondary schools and later expanded to cover more schools both in rural and urban areas. As narrated;

"We started with three schools as we introduced the platform..., the number of customers however grew and we had around 50,000 clients in our learning management system at the end of year one..., we managed to raise the number to over one million within the first three years with the frequency of users being higher during holidays..., the early users were located in big cities..., having created partnerships with telecommunication companies, we managed to reach extremely rural areas..., (Case 2_32-34).

Breadth

Regarding the extension of services to more people in currently served categories and localities, all the implementers of the innovations admitted that project activities whether having teachers or students as direct beneficiaries are also influenced by the immediate school management and/or leaders particularly Heads of school, the quality assurers, ward education leaders and the community leaders. The existence of these categories made it important to increase the breadth of their services by building the capacity of these categories to ease the piloting and/or implementation of the innovations at the school, as further narrated.

For case 1, besides building the capacity of education leaders along implementing the innovation, researchers and project implementers developed interest to establish how teachers share knowledge after receiving capacity building training. As narrated;

“Researchers are interested to establish the extent to which trained teachers share knowledge with their colleagues..., we have also introduced learning and sharing sessions where all the project direct beneficiaries [teachers, heads of schools, ward education leaders, quality assurers and district education leaders] meet and share progress...” (Case 1_24).

Case 2 targeted students as the initial direct beneficiaries. Later, the need for adding teachers as other beneficiaries arose, where teaching resources such as lesson plans were uploaded in the platform. As narrated;

“Students were our main beneficiaries, they were the ones mostly affected as they lacked access to learning content and resources..., through progress monitoring, we received questions and comments from teachers that improved our content..., we finally added some tools for teachers such as lesson plans, tools that enable for interaction with other teachers..., we also added online professional development courses for teachers...” (Case 2_23).

During the COVID-19 era we further added parents given their new roles towards offering guidance to their children regarding access to learning resources. As narrated;

“With the advent of COVID-19 [2020], the role of parents towards supporting their children along learning emerged..., we added in our website a dashboard to enable parents to ask questions..., they could also receive test results for their children..., we also added a content meant for child care for learning and sharing among parents...” (Case 2_33)

Furthermore, and to enable for inclusion and access to education to the marginalized, the implementers of Case 2 have also added a content for students who are out of school, to enable them access resources to facilitate transition into the formal education system.

Depth

Regarding extending additional services to current clients, all cases have introduced new services to their beneficiaries. For case 1, a WhatsApp group has been created among teachers, college tutors, education leaders including the heads of schools, Ward education leaders, quality assurers and the district education officers to share

progress and communicate new information along with implementing the innovation. The exchange of knowledge in this modality has bridged the gap between teachers and their leaders creating a harmonious working relationship. Schools also conduct exchange visits where school teachers visit each other to observe how the innovation is implemented in their context thus learning best practices. As narrated;

“The WhatsApp group has created friendship and linkage among schools implementing the innovation as they learn new knowledge and emulate what others are doing considering their school environment..., teachers have now developed a harmonious working relationship with the ward education officers and quality assurers..., before they used to see them as inspectors..., they were not approachable..., the project has then created a productive working relationship...” (Case 1_16).

It was also important to introduce learning and sharing sessions among the trained teachers and the education leaders to assess progress and improve further the practice. As narrated;

“Learning and sharing started in 2017..., we came to learn that once teachers are trained..., they don’t get an opportunity to learn from each other..., it was as if we let them practice on their own..., so we call them with their schools heads..., we also invite the ward education leaders and the quality assurers..., every school present progress report..., so are the education leaders based on their monitoring visits..., the team learn from one another the best practices and areas of improvement..., ” (Case 1_34).

For Case 2, the implementers started using a website to upload its content with learners accessing them in both online and offline modalities. Through research, the implementers came to realize that 7 out of 10 families own mobile phones, with this necessitating the introduction of a new product “Makini²” to enable the access of content through mobiles. As narrated;

“In 2017, the government statistics show that at least seven out of ten families own mobile phone in Tanzania, we established the sms system called “makini”, through which students register for an account and create individual classroom on the subject of interest and start learning..., For example, if algebra as a topic has six sub-topics..., the learner can interact with the content one after the other..., respond to the related questions and receive feedback with support from the system..., at first we started with question and answer..., this was followed by a teacher who could respond to students’ questions..., but now we use artificial intelligence, where students receive immediate feedback...,” (Case 2_21-22).

The implementers further developed a content on life skills to enable learners acquire soft skills and thus becoming lifelong learners. As narrated;

“We partnered with one NGO and came up with relevant content for learners in the current era..., for example we worked with XYZ bank where capacity building training on financial literacy is offered to primary, secondary and university students...,” (Case 2_81).

² Literally translated as “Pay attention”

Ownership

Regarding decentralizing the ownership of the innovation to other potential adopters; For Case 1, the implementers conducted an impact evaluation and communicated the results, mostly the achievements realized to different actors along with implementing the project activities. The practice has made other actors develop interest to continue scaling up the innovation to new schools. As narrated;

“One funder declared interest to contribute to improving the school environment through mathematical gardens..., [particularly] cultivation of vegetables and fruits to be used for learning purposes..., (Case 1_77).

The implementers have also managed to get funding that enabled the scaling of the innovation to secondary level in Tanzania, Kenya and Zambia, also a spread component of scaling. The 30 months’ project is ongoing and will end in October, 2023. The implementers further encourage district councils to scale up the innovation in schools that have not benefited from the initial piloting. As narrated;

“We continued encouraging education leaders to scale up the innovation to schools that did not benefit from the innovation..., two districts managed to scale up the innovation..., district XYZ for example implemented the innovation in 35 schools making a total of 70 benefiting from the innovation..., initially we piloted the innovation in 35 schools of this district..., another district also doubled the number of the initial schools making a total of 40 adding 20 to the ones we piloted...,” (Case 1_67).

For Case 2, the implementers have been working with the institute of curriculum development, teacher college tutors and teachers from the initial design with this making the institutions and participants own the process. As narrated;

“We worked with the Ministry of Education through its agency, the Institute of curriculum development, whose role was to approve the online content. Until 2013, the Institute used to deal with book publishers and not producers of online curriculum content..., they then gave us experts who build the capacity of our teachers on how to design online content..., the content was further reviewed and approved for usage..., the institute later created a portal for our content..., to date, six out of our ten subjects have been certified..., An agreement has been entered between us and the Ministry responsible for administration of schools through school improvement system which now integrates our content for public use..., we have over 3.5 million users through our platform, but in their website there are more users...” (Case 2_26-27).

Problem Definition

Regarding extending current methods to new problems, all innovations managed to address other problems beyond the ones stipulated from the initial design. For case 1; the innovation revitalized the teaching of mathematics. Students now positively perceive the subject of Mathematics, since the innovation module relates mathematical concepts with real life application making the concepts more practical. Through the innovation a committee of local education leaders (Heads of schools, Quality Assurers Trade union, Ward education leaders and district education officers) has also been created to conduct overall assessment of school performance thus coming up with areas of improvement based on the assessment report.

For case 2, while there existed different modalities for providing educational resources to learners in the Tanzania education system, the innovation was the first platform to offer standardized resources that augment the national curriculum at the secondary level through technology. There also exist guidelines for education provisions as provided by the Ministry of Education, Science and Technology, including curriculum and teacher professional development framework. The innovation has now attained the advanced level of technology integration as it enables for learners' interaction with the resources. As narrated;

"We came to realize that most of the supplementary education resources as provided by different actors are not regulated..., the responsible Ministry of Education offer guidelines and curriculum, with the delivery content and platform taken care of by the actors..., we wanted to create interactive supplementary resources for secondary school students that conform to the Tanzania education standards and regulated by the national institute of curriculum development..., while at the same time transiting from the traditional model of education to digital model..., students could read, ask questions, receive feedback..., we see this as an opportunity..., so we started working with XYZ teacher college to create the content along the guidelines..., (Case 2_5-6).

Relevance of Technology in Scaling Education Innovations

The study found out that the study innovations use technology to market their innovation and to communicate among beneficiaries along implementing the project activities, with this dependent on the nature of the innovation. Accordingly, teleconferencing tools particularly Zoom and Google meet, website and WhatsApp as a social media were the ones reported to be mostly used by the study innovations. The relevance of technology is further expanded with illustrations.

Marketing and Dissemination of the Innovation Outputs

The innovations use different social media to market and disseminate their outputs. Case 2 for example uses both the word of mouth as well as technology particularly social media (whatsapp, tweeter) to market the innovation enabling for its spread, depth and ownership. To reach remote areas, the implementers partnered with telecommunication companies and used their infrastructure enabling rural coverage. As narrated;

"When we started, we used the word of mouth to market our innovation..., our wish, was to reach the most rural areas..., we partnered with telecommunication companies to extend their services in the rural areas and we extended our services in these areas..., through this we reached 100 schools that are located in very rural areas..., (Case 2_25).

Accordingly,

"During COVID-19, we entered into agreement with telecommunication companies to enable our users to access the platform resources without paying for internet data ..., (Case 2_29).

Technology Integration Along the Samr Framework

For case 2, the platform has replaced some of the tasks that were done on a face to face modality, a typical example is the submission of students' assignments online with this increasing the depth of the innovation. Mobile phones are also used to deliver resources to learners. Furthermore, since the content is interactive, it enables for individualized learning encouraging ownership and learner-centered approach with this reflecting the Augmentation, Modification and Redefinition aspects of the SAMR framework. The design of the content further considered inclusiveness as it addresses diverse learners' learning difficulties. As narrated;

"Interactive tasks are now created online for student's access beyond the normal classroom hours, anywhere and anytime..., learners also have different learning difficulties..., some are blind..., others are deaf..., others demonstrate different levels of understanding..., some have learning difficulties yet to be recognized..., so the platform provides for these learning variations enabling diverse learners to learn depending on their ability and learning styles..., they can listen, draw, perform create works, writing and so forth.....," (Case 2_14).

The platform also enables students to do examinations and thus minimize the related costs for printing and administration. As narrated;

"If secondary school students are provided with laptops, the platform can be used to administer examinations thus reducing the time for producing examinations and the related costs such as purchase of stationery and the related manpower supervision...,," (Case 2_10).

On the augmentation, teachers can also customize the online resources for classroom usage, with this aligning to the depth aspect of scaling. As narrated;

"Teachers can create their own content and questions with reference to the platform content to address the needs of the diverse needs of learners....," (Case 2_18).

Enhanced Communication Among Project Partners and Beneficiaries

Case 1 for example uses technology particularly WhatsApp to communicate with the project beneficiaries to share progress and monitor project implementation. Technology in this regard, enables for the spread, depth, breath and ownership of the innovation. It also aids data collection during baseline, mid-line and end-line evaluations making it possible to support the implementation of the project activities. As narrated;

"Technological tools such as WhatsApp groups are used to share learning resources among participants and new developments. Adverts are also posted in the WhatsApp group to create awareness enabling for immediate feedback from the beneficiaries. Other technological tools include Kobo tool, which is used for data collection in both online and offline modes. SITT also uses BANANA as a tool to monitor project expenses...,," (Case 1_45).

Furthermore, online teleconferencing tools such as Zoom, Google meeting are also used to enable for project meetings, conducting interviews during evaluation sessions as well as team teaching.

DISCUSSION AND CONCLUSION

The study aimed to explore how two education innovations in Tanzania managed to scale up using technology as an enabler along the scaling dimensions of spread, breath, depth, ownership and problem definition according to Coburn (2003), Clark & Dede (2009) and Cooley (2016). The findings show that all the innovations align to the study scaling trajectories and use different technological tools to realize scaling. Study findings further found out that teleconferencing tools such as Zoom and Google meet are used to conduct meetings and coordinate various activities of the innovation along the scaling process. Social media tools such as WhatsApp as well as learning management systems are also used to deliver content as well as sharing progress among the implementers of the innovation and the beneficiaries. Kobo tool is also used to collect evaluation data enabling for real time information, also aiding the analysis process. Studies such as those by OECD (2016), Sedukyov (2017) share similar views that related technological tools are used to facilitate the scaling of education innovations. Indeed, most studies show the application of digital technologies to evaluation the impact of the innovations and strengthening collaboration among actors (Ng, 2009; Smith, 2009; Popescu and Creniecean, 2012;) as well as spreading the innovations geographically (Mykhailyshyn et al., 2018; OECD, 2016).

Besides the application of technology in scaling, the sustainability aspect of education innovations has been a challenge among the actors involved from the design of the innovation, to the process of implementing it and the dissemination aspect. To design for scale, the innovation approaches should be done through government systems in order to reach a significant scale of adoption and thus be sustained within institutional structures and systems (Vvob, 2021). According to Cooley (2016), government institutions are in a better position to fund and deliver either directly or indirectly most innovations sustainably at scale, also facilitating access to the population at risk especially the marginalized. In the process, Dede (2016) concludes that, designing an innovation for sustainability and scaling is iterative and a multi-stage engagement and should aim to empower teacher directed designs that can be adapted to their local circumstances, views also shared by Barab and Luehmann (2003). In this regard, teachers should be viewed as co-evaluators and co-designers in the process. Additionally, the design of education innovations to be scaled should be a) robust through using contextual evidence to retain their effectiveness in the new contexts; and b) flexible to enable for adaptation in a variety of contexts across a spectrum of learners and teachers (Dede & Knox, 2009; Dede, 2016). Indeed, the needs of different education stakeholders considering the supporting structures such as school leadership, culture, administration, parents, communities, and the government should also be considered (Dede, *ibid*; Fuad, Musa & Yusof, 2020) along the design and piloting processes.

Regarding the quality of scaling education innovations, Vvob (2021, p. 2) recommends for four aspects; a) a strong instructional core that demonstrably improves learning;

b) effective teacher and school leader professional development delivered at scale; c) widely available high-quality low-cost teaching and learning materials to accompany professional development; and d) context-sensitive, long-term capacity development support to government institutions at different levels of the education system. Most of these aspects were adhered to in the study innovations.

On technology, the existing education innovations need to be scaled up to serve many students, teachers and the marginalized populations, with this practice not fully realized in research compared to innovations in other sectors (Shelton, 2011; Serdyukov, 2017; OECD, 2016). Additionally, the implementation of technological innovation should align with the existing leadership, pedagogical theories, and research in education (Fuad, Musa and Yusof, 2020; Serdyukov, 2017). Fortunately, the study innovations managed to create ownership and strong partnerships that enabled the realization of scaling.

Challenges such as supply driven innovations, over dependence of technological solutions to instructional programs, higher expectations from teachers to invest more time and effort than they were willing to provide on the intervention as well as the implementation of the initiatives outside government systems have also been found to negatively affect the scaling process (Piper et al, 2018). Thus, building the institutional capacity of an education system, where the implementers of the innovations such as teachers and school leaders are enabled and supported to integrate the new approaches is the key to realize optimal impacts of scaling (Peurach & Glazer, 2012; Hung et al. 2014).

Study recommendations and areas for further research

The study innovations on the one hand, managed to use technology to scale up their innovations along the scaling dimensions. On the other hand, scaling was possible due the strong partnerships that the implementers created with different stakeholders including the key government agencies, with their presence enabling for scaling and the sustainability of the innovations. Indeed, research shows that scaling education innovation demands financial resources and the government will follow the process for sustainability purposes (Fuad, Musa and Yusof, 2020; Kohl, 2021; Vvob, 2021). Since there exist different innovations that are not scaled up due to various reasons including the aforementioned, there is a need to map all these innovations and the related actors to explore possibilities of soliciting funding to scale up the most promising innovations for wider benefits. Designing for scale further demands integration of scaling along the design process, the aspect that is not considered by many innovations (Kohl, 2021). Capacity building in this regard is important to enable the designers of education innovations to have the scaling mindset along the design process. Different stakeholders, especially teachers as the key towards the implementation of the innovations need also to be involved from the initial stages of the design to enable for ownership and effective implementation of the design (Looi & The, 2015; OECD, 2016).

Regarding the application of technology in scaling education innovations, the study findings show that each innovation uses technology differently. In this regard,

conducting individual case studies of innovations stipulating how each uses technology could provide for a more thorough analysis of the findings.

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