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How do educational technology enterprises improve learning outcomes in developing countries through technology-mediated learning?

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Abstract

This dissertation explores the role of educational technology enterprises (ETEs) in improving learning outcomes in developing countries through technology-mediated learning. It aims to contribute to the growing body of literature on the use of EdTech in emerging economies by adopting a novel approach – examining the provision of educational technology by private enterprises, in contrast to much more prominent user-focused research. Qualitative analysis presented in this dissertation leans on primary data gathered in semi-structured interviews with executives of ETEs operating in developing countries and takes form of a case study of five enterprises – Ubongo, EnCube Labs, Gradely, Open Learning Experience and Can't Wait To Learn. I assess the emerging theories on the vision of learning that ETEs adopt, the prerequisites for implementation of their intervention methods, the role of human educators in those enterprises, their coexistence with formal education and, most importantly, the process of ETE sustaining change and scaling up. It was discovered that ETE scalability plays an important role in improving learning outcomes in developing countries and two factor categories are particularly conducive of it – implementation partnerships and financing. Additionally, this dissertation established and formulated the "country-language" principle of ETE scaling.

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Chapter 1: Introduction

1.1 Current context

Since educational technology ("EdTech") emerged as a field of research in the 1970s, it has often been marketed as a panacea to all woes of educational policy. In the past decades the global education sector has become heavily engaged with various EdTech initiatives (Niederhauser et al., 2018) from providing access to technology to data-driven learning tools. More recently, scholars and policymakers became increasingly interested in EdTech as a solution to overcome the education sector's challenges in developing countries (Reeves and Reeves, 2015), such as lagging learning outcomes, low retention and graduation rates and socioeconomic inequality (Rodriguez-Segura, 2021). During the COVID pandemic technological learning interventions have received even more attention, as millions of children in emerging economies lost access to traditional education services (Crawfurd, 2020). However, despite the rapid expansion of the global EdTech market (MarketStudyReport, 2021), development of new intervention techniques and growing interest from researchers and politicians, we are yet to witness a wide-scale adoption of educational technology, especially in emerging economies, as exemplified by the fact that over 400 million children in Africa (out of 450) do not use any EdTech in their learning (Crawfurd, 2020). Overpromise and underachievement of EdTech initiatives are often exemplified by one laptop per child ("OLPC") programs (Cristia et al., 2017), which gained traction and attracted widespread public support and investment, but have been shown to be ill-effective and low-value interventions (Kraemer, Dedrick and Sharma, 2009) in many cases.

Thus, the process of dissemination of educational technology across socio-economic and cultural contexts in developing countries is central to understanding how EdTech could improve learning outcomes there. While educational technology interventions in developing countries are implemented both by governmental and private actors, the growing influence of "business-driven companies" on the global educational landscape (Renz and Hilbig, 2020) and rising venture capital investment in EdTech firms (Koba, 2015) hint at an increasingly prominent role of private educational technology enterprises ("ETEs") in improvement of learning outcomes through technological interventions in developing countries. Therefore, this dissertation approaches the topic of improving learning outcomes in emerging economies in a highly novel way – through investigation of the (private) supply side of the provision of EdTech.

The majority of educational technology research focused primarily on developed countries due to their higher saturation with EdTech initiatives and enterprises, easier data gathering, access to better communication technology and friendlier policy environment. However, the challenges that education sector faces in emerging economies are often drastically different (Rodriguez-Segura, 2021) and thus implementation of educational technology in developing

countries requires separate academic attention. Only recently have academics began gathering meta-analytical data on effectiveness of particular EdTech interventions in developing countries (Rodriguez-Segura, 2021; Major et al., 2021). These and other studies of EdTech in developing countries have tended to focus on the demand side of EdTech, such as effect on learners and other user-related issues. Furthermore, very limited research exists on sustainability and scalability of EdTech enterprises in general (Niederhauser et al., 2018; Renz and Hilbig, 2020).

1.2 Aims and objectives

This work aims to contribute to the growing body of literature on educational technology in developing countries by focusing particularly on the study of EdTech enterprises, an area which has received very little academic attention thus far. The field of educational technology research is criticised by some as methodologically weak (Bulfin et al., 2014) and under-theorised (Jones and Czierniewicz, 2011; Markauskaite and Reimann, 2014). This study responds to the request for "more middle-range theories" in EdTech research (Hew et al., 2019) by applying technology-mediated learning theory (Bower, 2019) framework to the qualitative empirical analysis of EdTech enterprises' work in emerging economies, based on and validated by five case studies – Ubongo, Open Learning Experience, Can't Wait To Learn, EnCube Labs and Gradely. Ultimately, this study answers the following research question:

How do educational technology enterprises improve learning outcomes in developing countries through technology-mediated learning?

To answer this question I analyse the opportunities that EdTech enterprises make use of to deliver learning, the mechanisms through which they do so and the paths they take to successful scaling. This study answers the research question through the interrogation of the following sub-questions:

How is learning envisioned within educational technology enterprises?

What material practices are employed by them to improve learning outcomes?

What factors contribute to their implementation, sustainability and scaling up?

By combining the theoretical conceptualisation of technology-mediated learning with empirical analysis of the workings of EdTech companies, this study aims to bridge the 'relevance gap' (Merton, 1949) between theory of learning and the practice it observes, manifested in the varying approaches to delivering education in developing economies that the studied enterprises adopt. Ultimately, this study will:

1. Examine the approaches to delivering and measuring learning within ETEs
2. Assess the factors required for the successful implementation of these approaches
3. Identify limitations to sustainability and scalability

1.3 Scope and structure

It is beyond the scope of this dissertation to quantitatively evaluate the effectiveness and cost effectiveness of any given intervention technique or ETE business model. Instead, the focus is on the opportunities that EdTech enterprises make use of to implement their models and what approaches they take to growth. The qualitative research relies on cross-case analysis of five enterprises – EnCube Labs, OLE, Can't Wait To Learn, Ubongo and Gradely – facilitated by the data gathered in semi-structured interviews with the companies' leadership and supported by secondary data and broader literature.

Chapter 2 of this dissertation presents a theoretical review of the academic literature most relevant to the studied topic, discussing the present state of EdTech in developing countries, the existing evidence on effectiveness of different types of interventions, theoretical conceptualisations of learning and technology-mediated learning theory in particular, sustainability and scalability of EdTech initiatives and the question of their co-existence with formal schooling. Chapter 3 discusses the methodology of qualitative research undertaken, while Chapter 4 present the findings of empirical research. Finally, Chapter 5 contains the discussion and analysis of the findings.

Chapter 2: Literature review

2.1 State of EdTech and ETEs in developing countries

Educational technology is increasingly gaining attention as a promising avenue for addressing educational policy needs in developing countries (Bianchi et al., 2020). As its potential applications increased and its reach expanded, technology has become a basic input into the provision of educational services even in emerging economies (Rodriguez-Segura, 2021). The global EdTech industry has been valued at USD 17.7 billion in 2017 with expectations of further rapid growth (Frost and Sullivan, 2017) which it fulfilled, reaching an estimated value of USD 74.64 billion in 2019 (MarketStudyReport, 2021) and a projected value of USD 404 billion by the year 2028, which would still only constitute about 5.5% of the global education market (HolonIQ, 2020). The Chinese EdTech market has been at the forefront of this expansion, particularly during the COVID pandemic, having grown 118% between 2018 and 2020 up to USD 48 billion (Shleifer and Kologrivaya, 2021).

Importantly, recent years have seen a rise in influence of private businesses on the educational market (Renz and Hilbig, 2020), particularly EdTech enterprises providing "data-based teaching and learning solutions" – from tech giants like Google and Netflix to SMEs and startup-sized companies. This development opens a brand new avenue for potential research as very little is currently known about how such enterprises implement their solutions and grow. Meanwhile, it is this growth that presents a promising path for the spread of educational technology, particularly in developing countries. This dissertation gathers existing theory and empirical evidence on the work and growth of EdTech enterprises in emerging economies and hopes to noticeably advance this area of research.

While the education industry is growing, this expansion does not reflect other important metrics, such as a more egalitarian reach to all learners or incorporation of tested technologies and methods (Rodriguez-Segura, 2021). An analysis of a database of EdTech firms conducted by Crawfurd (2020) shows that just 19 million children in Africa (out of 450 million) were using any educational technology before the COVID crisis, most of them being viewers of a TV show produced by Ubongo. Crawfurd estimates that this figure has approximately doubled during the pandemic. The EdTech Hub database studied includes mostly companies from Africa. Of those, the majority was located in only three countries – South Africa, Kenya and Nigeria. Crawfurd (2020) emphasises that innovation and investment in educational technology is encouraged by larger market size, which in turn is dependent upon factors like population size (especially of children), its purchasing power and language. This suggests that ETEs are incentivised to concentrate in higher-income areas, potentially worsening educational gaps between regions, socioeconomic groups and countries. Similarly, they are supposedly likely to scale up along linguistic and technological barriers, not across them. Chapter 4 of this study discusses the empirical findings on scaling strategies of ETEs.

The effectiveness and cost-effectiveness of EdTech as a solution to educational policy needs in developing countries largely remains an open question due to lack of systematic evidence (Rodriguez-Segura, 2021). EdTech has the potential to address some of the most pressing issues of the education sector, including tasks such as providing individually-tailored instruction, content and assessment on ultra-large scale, something that is unfeasible with existing pupil-teacher ratios. However, on a more practical level concerns remain whether EdTech can outperform more archaic approaches penny-for-penny, whether weak state capability would be a hinderance, and whether low access to inputs such as electricity, internet or hardware could be a problem (Rodriguez-Segura, 2021). Indeed, the issue of technological poverty remains a challenge in the developing world. In Sub-Saharan Africa access to electricity remains at 48% (World Bank, 2018). Moreover, the issue of technological gap between socioeconomic groups within countries is also very serious. In Mexico and Peru, 94% of top income quintile households have access to computers, while less than 10% of lowest quintile households do (Rieble et al., 2020). In Africa, 82% of richest households own a TV, while only 4% of "poor" households do (World Bank, 2020). The following section examines in detail the existing evidence for effectiveness of varying

EdTech interventions in developing countries, beginning with the issue of access to technology.

2.2 What problems does EdTech (attempt to) solve?

One way to begin assessing EdTech enterprises is the underlying effectiveness of the technological intervention methods utilised. While in practice only a share of educational programs are led by entrepreneurs or private organisations, their effectiveness tends to depend on the intervention type, as the following discussion shows. Daniel Rodriguez-Segura (2021) has compiled a comprehensive review of the studies on educational policy interventions in developing countries involving a technological tool, totalling 81 original papers with credible causal identification frameworks. These interventions are classified into separate categories reflecting their design features and goals. Rodriguez-Segura follows a similar classification used by Escueta et al. (2020), but adjusts it according to differences in policy issues and intervention methods between developed and developing countries. The resulting four categories are (1) access to technology, (2) tech-enabled behavioural interventions, (3) improvements to instruction and (4) self-led learning. I now discuss the significance, underlying effectiveness and cost considerations of each type.

Access to technology

A quarter of the studies evaluated by Rodriguez-Segura (2021) are focused on access to technology. Such interventions are based on the idea that EdTech could effectively deal with the issue of lacking material school inputs such as textbooks, paper, blackboards, chalk, writing utensils, by providing pupils with their technological substitutes and consolidating such inputs into a few electronic devices. Indeed, absence of school inputs is a binding issue in emerging economies. For instance, between 2013 and 2016 only a fifth of Tanzanian schools had a library with books (Mbiti et al., 2019).

A prominent and comparatively old example of an access to technology intervention is the one-laptop-per-child (OLPC) policy. It involves governments and NGOs specifically targeting the computer-pupil ratio in schools, aiming to bring it up to 1:1 by providing students with devices or building computer labs large enough for each child to have a laptop to themselves. This is an attractive idea as it requires very little beyond financial investment into infrastructure and/or computers. Indeed, investments to increase access to technology became a policy priority even in lowest-income countries (Kozma and Surya Vota, 2014). However, OLPC policies lack a coherent causal mechanism of improving learning outcomes and instead rely purely on the positive "spillover" effect from having access to technology. In practice, OLPC-type interventions have been shown to generally have little to no effect on scholastic achievement (Cristia et al., 2017; Kraemer, Dedrick and Sharma, 2009) while also being high in cost, making it a low-effectiveness and low-value intervention. Despite the lack of evidence on improved learning, some studies have reported improvements in familiarity with technology and "digital skills" (Bet et al., 2014; Malamud et al., 2019). This could result

in higher effectiveness of future technology-related interventions or a lagged improvement in learning outcomes over the long-term.

Papers studying the provision of handheld devices, rather than computers, have shown mixed results, with more positive effects reported (Rodriguez-Segura, 2021), however the most convincing cases involved an important element of in-person teaching support (e.g. Pitchford, 2015), suggesting that the more "effective" component of the intervention lies outside the domain of "access to technology". The most salient exceptions in regards to raising student achievement levels were measures involving large-scale provision of high-level access to technology (Rodriguez-Segura, 2021). These included providing internet access in Peru and electrification in Tanzania. All of those target the issue of technological poverty in a large region, improving local infrastructure and leading to a wide range of quality of life improvements. However, such programs are government-driven and are barely feasible for an ETE.

Overall, access to technology interventions target low penetration of technologies capable of hosting educational features. They are characterised by very low effectiveness for academic achievement with an upside of improved familiarity with tech, while also being low in cost effectiveness due to high marginal cost and questionable efficiency (Rodriguez-Segura, 2021). More effective measures could be crowded out by increased attention to access to technology policy-wise. However, providing such access is a necessary platform for implementation of further, more effective solutions. The empirical part of this study would discuss in more detail how educational technology enterprises deal with the issue of access to technology through utilising existing capacities and enhancing them.

Technology-enabled behavioural interventions

Interventions in this category consist mainly of two types – (1) accountability interventions for teachers and (2) informational interventions for parents, students and schools. The first type involves targeting issues like teacher absenteeism or low rate of on-task instruction through measures such as introducing cameras reporting teacher presence or requiring teachers to take frequent pictures with students to prove presence, on which a portion of their pay would be conditioned. These interventions have shown positive albeit moderate effects on learning outcomes (Rodriguez-Segura, 2021), in sharp contrast to other methods of increasing teacher effort such as raised pay, exemplified by a study in Indonesia that permanently doubled the salary of teachers which has shown zero improvements in student learning (de Ree et al., 2018).

Informational interventions involved high-volume messaging, such as SMS, often crafted using insights from behavioural science, aimed at addressing information asymmetries between students, teachers, pupils and school stakeholders. Such interventions have shown low to medium positive effects on learning and high cost-effectiveness due to very low marginal cost once the automated system is established (Rodriguez-Segura, 2021).

Overall, interventions of this category are characterised by high cost-effectiveness when it comes to targeting information barriers, stakeholder incentives, policy enforcement and accountability, but require both focused and contextual knowledge of behaviours and how these can be shaped with low-resource techniques.

Improvement to instruction

This category is comprised of interventions that are aimed primarily at improving the quality or effectiveness of teacher instruction. Previous sub-section discussed interventions targeting teacher engagement and effort, which could be a problem in many developing countries, however, even if the teacher is engaged, their own mastery of the content they are intended to teach is often questioned. A recent study on teachers in El Salvador found that an average teacher scored just 47% on a 50 question math test based on second to sixth grade curriculum (Brunetti, 2020), suggesting that the situation with teacher content knowledge may be even worse than previously suggested by studies using indirect measures. Thus, it is believed that EdTech could be used to supplement or even substitute traditional instruction methods, easing the burden on teachers, which is a notion further discussed in section 2.5.

Three intervention types are highlighted within this category – (1) remote instruction, (2) shaping of classroom instruction and (3) remote engagement with teachers and parents. All of these involve broadcasting live or pre-recorded audio- and video-content via the internet, TV, radio or other ICT. These interventions are aimed at addressing the gaps in teacher knowledge, difficulties with intake of competent staff in numbers required for quality instruction or limitations to scaling training programs. They are characterised by medium to large effects for improving learning – with the median effect among reviewed studies of 0.28 SD (Rodriguez-Segura, 2021) – and high cost-effectiveness due to low marginal cost of new users (e.g. of an online teacher training program) once the set-up is completed and fixed costs are paid for. While there are potential risks of damaging instruction quality with improper introduction of technology exemplified with a study by Berlinski and Busso (2017), the overall results are highly promising and what is particularly attractive is that "improvement to instruction"-type interventions could be deployed successfully in the most problematic areas where the quality of teaching is significantly lagging and attracting resources is problematic.

Self-led learning

While also serving as a solution to lack of quality instruction, the interventions of the "self-led learning" category are characterised by higher degree of independence from teachers, instead relying on technology to deliver learning material directly to students with adjustments according to optimal pace and skill gaps. Thus, improvement to instruction is not necessarily the mechanism of achieving improved learning, but establishing brand new avenues for content delivery is. These interventions respond to similar issues as "improvement to instruction" – increased burden on school resources and staff, caused largely by exploding enrollment rates with number of primary school children growing by 350 million between 1970 and 2018 (World Bank, 2021).

Self-led learning initiatives are normally manifested in provision of software (usually self-adapting or integrated into a form of learning management system) that supports training and exercising certain skills (typically math and language) or simply provision of online classes. Among the software evaluated in studies reviewed by Rodriguez-Segura (2021) medium to large positive effects on learning outcomes are reported, with median effect size of 0.29 SD and 75th percentile at 0.46 SD. The interventions are best applied to complement instruction and fill in content gaps. Again, cost-effectiveness tends to be quite high due to the majority of costs being fixed. However, software is limited by languages, subjects and context, meaning that successful scaling and penetration of such technology requires developing new software for different circumstances and languages.

Summary

The four categories discussed in the section above are not necessarily "mutually exclusive", despite Rodriguez-Segura (2021) referring to them as such. As he acknowledges, a given policy intervention may not fit neatly into any given group. Indeed, some of the more effective initiatives involve a healthy combination of different approaches (e.g. Pitchford, 2015) and attempt to acknowledge many existing problems and challenges in their set-up. Chapter 4 further discusses how real EdTech enterprises combine different approaches in their work. Regardless, this classification provides a comprehensive overview of the existing policy directions in the realm of educational technology, evaluating their general effectiveness in relation to learning outcomes and the present causal mechanisms of achieving learning through technological measures.

2.3 Learning theories and technology-mediated learning

As mentioned in the previous section, the effectiveness of any educational intervention is often dependent on the understanding of specific causal mechanisms leading to learning grounded in both theory and practice. This section considers technology-mediated learning theory (Bower, 2019), the primary theoretical conceptualisation of learning that present dissertation adopts in its discussions of said phenomenon, as well as the broader context of learning theories that technology-mediated learning theory (TMLT) has emerged from – particularly, Vygotsky's social development theory, constructivist theory of learning and Actor-Network Theory (ANT).

The works of Lev Vygotsky (1934/1986, 1978) have paved the way for educational researchers to construct a more nuanced understanding of learning processes, departing from the purely behavioural explanations of learning and cognition, as exemplified by Pavlov (1928). Vygotsky introduced the all-important element of social interaction, acknowledging that it plays a fundamental role in human learning. According to Vygotsky, learning involves the process of internalising to a personal intra-mental plane what has been witnessed in an interaction with others who have successfully internalised that learning before (Taber, 2020).

He introduces the notion of the "more knowledgable other" as crucial to development and postulates that learning is highly contingent on social interaction and cultural context, rather than being a purely internal process.

Additionally, Vygotsky (1978) introduces the ideas of tools and mediation (Figure 1), central to our subject. Tools could be immaterial or even symbolic (such as numerical systems or formulae) and are seen as another channel for mediating learning similar to the "more knowledgable other". Tools are also inherently social – even when one is, for instance, solving a problem alone using algebraic formulae, the mediating tools are provided through culture and the knowledge of how to apply them arose from previously mediated learning. Dying in 1934, Vygotsky preceded the advancement of high-end technology into mainstream education, but EdTech has only reinforced his vision of development by serving as the most prominent example of tool-mediated learning.

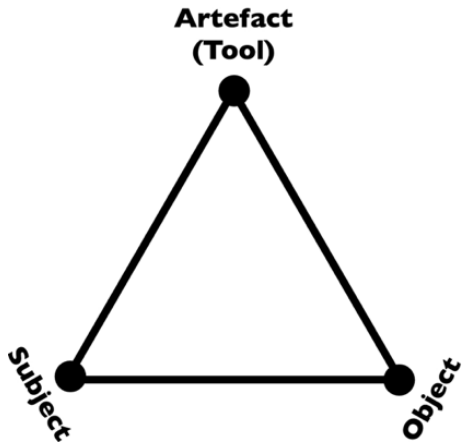

Figure 1: the general form of a semiotic triangle, from Taber (2020)

Vygotsky could be considered a constructivist in a sense that he took knowledge to be actively constructed, rather than innate to the human mind and revealed through contemplation or gained purely through individual sensory mechanisms (Taber, 2020). However, contrary to his contemporary and another prominent constructivist Jean Piaget, who focused on the learner's actions in and on the environment as an active constructor of knowledge (Piaget, 1932/1977), Vygotsky considered the social to be the central aspect of human learning.

Yet over time, researchers had began questioning the extent to which "social" can provide an adequate explanation of educational phenomena (Kamp, 2019). Bruno Latour, the key figure associated with emergence of ANT, has pointed out that the need arose to "scrutinise more thoroughly the exact content of what is 'assembled' under the umbrella of a society" (2007). In order to do so this new materialist approach considers dynamic assemblages of humans and nonhumans and takes the social to be "the name given to momentary associations when fluid entities gather in a particular configuration" (Kamp, 2019). Thus the focus shifts from society as something established and given to society which needs to be studied in its

multidimensional complexity in each specific context – instead of studying the "social" as something solid, researchers now attempted to examine the processes which shape its dynamic nature. One problem is, despite being referred to as such, ANT is not precisely a theory (Law, 2009). Instead, it is deeply rooted in the empirical and exposes the infinite, almost unstudiable complexity of the processes it wishes to describe. ANT is an approach concerned with "rendering visible a diverse range of actors and exploring their work of translation as either intermediaries or mediators" (Taber, 2020).

Technology-mediated learning theory, as schematically represented in Figure 2, conforms to many general principles of ANT, but is (1) subject-specific to technology-enhanced learning and (2) clearly presents its theoretical assumptions and premises. TMLT establishes three main actors or actor categories – educator(s), learner(s) and technologies, locating them within a community and broader environmental context, as well as specifying their dynamic interaction mechanisms. Notice how this representation is similar to a semiotic triangle (Figure 1), characteristic of Vygotsky or Activity Theory, but is located within a framework à la Actor-Network Theory.

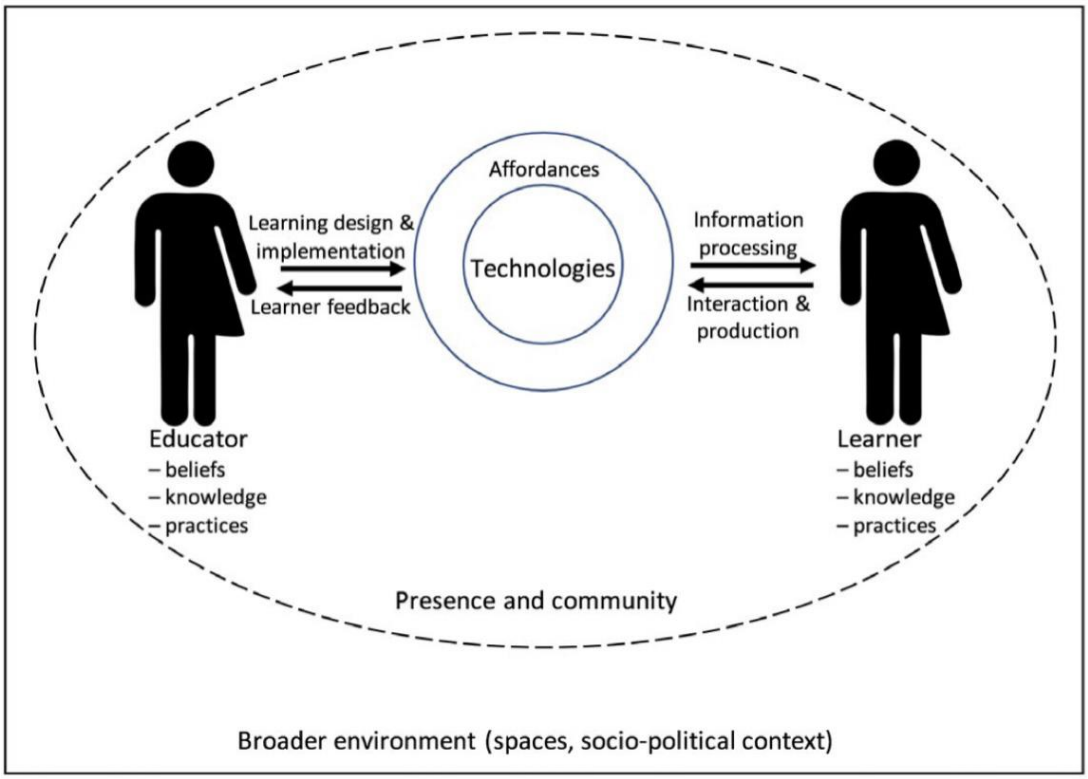

Figure 2: Schematic representation of TMLT, from Bower (2019)

The fundamental assumption of TMLT is: "in technology-mediated learning contexts, agentic intentions reside with humans, and not with technology" (Bower, 2019). This is a major point of departure from Latour, as asymmetry between humans and nonliving objects is created, manifested in the belief that only the former possess "intentional agency". The term "mediated" here accords with Actor-Network Theory in so far as it "leaves open the possibility that technology itself might unexpectedly transform what is communicated in

unintended ways" (Latour, 2005), but the technology is often approximated to a Latourian "intermediary", something that mediates without distortion (Bower, 2019).

The seven premises of TMLT are as follows:

1. Digital technologies can perform a mediating role for participants in their attempts to achieve learning goals.
2. In technology-mediated learning contexts, participant beliefs, knowledge, practices and the environment all mutually influence one another.
3. In technology-mediated learning settings, the role of teachers is to help optimise student learning outcomes and experiences through the purposeful deployment of learning technologies.
4. The affordances of technologies, including their recognition and use, influences the sorts of representation, interaction, production and learning that can take place.
5. The way in which modalities are used and combined influences the way in which meaning is processed, interpreted, created and interrelated.
6. The way in which technology is used to mediate interaction patterns and possibilities between networks of participants influences the learning that takes place..
7. Arrangements of technologies and the way they are used can influence the sense of presence and community that are experienced.

Specifically in the context of this study, TMLT allows us to categorise, label and locate processes and phenomena within a holistic, integrated interpretative system appropriate for all technology-mediated learning contexts. Additionally, TMLT provides a nuanced framework for analysis and comparison of different technology-enhanced learning context which remains theoretically consistent. Chapter 5 of this dissertation discusses the implications of empirical results of this study on theory advancement in relation to TMLT.

2.4 Sustainability and scalability

In practice, when it comes to EdTech enterprises, establishing the effectiveness of suggested intervention methods is only the beginning. Providing continuous positive impact and disseminating the initiative across social, economic, political and other contexts presents an equally challenging task. This section considers existing theory on sustainability and scalability of educational technology initiatives and its implications for the present study. In this context, *sustainability* is taken to mean "ongoing change", while *scalability* is the "dissemination of change across different contexts", following the definitions proposed by Niederhauser et al (2018).

Surprisingly little has been written by academics on sustainability and scalability of EdTech initiatives; not least of all because the entrepreneurial side of EdTech integration in general has not received much academic attention, as discussed previously. Broader research on diffusion of technology in educational contexts can inform some of our understanding of sustainability of such change. Evidence suggests that teachers' attitudes to digital technology

play an important role in technology diffusion in schools (Ertmer and Ottenbreit-Lefwich, 2010), although not all ETEs operate through schools. Communication patterns and interpersonal connections (Rogers, 2010), as well as administrative management and school leadership (Fullan, 2015) also influence innovative technology diffusion.

In a rare academic article focused on this issue, Niederhauser et al (2018) present three "challenges" which they suggest can inform the process of EdTech initiatives sustaining change and scaling up, validated through four case studies, including two developing countries – Ghana and Tanzania. These challenges are (1) establishing productive partnerships among stakeholders, (2) identifying research-informed approaches to technology integration that are sustainable and scalable, and (3) developing sustainable and scalable approaches to technology integration that are based on research literature rather than policy initiatives. Despite being valid points, particularly challenges 2 and 3 are highly tautological. The nature of what constitutes a "sustainable and scalable" approach to technology integration remains unclear and is conditioned upon itself. Authors (Niederhauser et al., 2018) discuss the need to build up knowledge on intervention designs and implement iterative research, but their advice is far from any practical considerations. In fact, Muralidharan and Niehaus (2017) explain in detail how public policies in developing countries (including those on education) severely lack evaluative research at scale. Instead, the effectiveness is tested on small samples and is followed by large-scale costly roll-outs straight away. Because of this, identifying specific factors influencing sustainability and scalability of EdTech solutions is critical.

One emerging school of thought on this is purely economical. As research discussed in section 2.2 shows, low marginal costs of implementation tend to correlate with higher cost-effectiveness and scalability. For many intervention types there tend to exist trade-offs between fixed and marginal costs, which significantly affect economies of scale and thus scalability (Rodriguez-Segura, 2021). For instance, OLPC policies have high marginal costs of enrolling a new learner – the full cost of a laptop, while text-message services can reach new people with little extra cost. This suggests that, in general, low marginal cost interventions have higher scalability potential. There are reasons to believe that EdTech could have some advantage over pen-and-paper alternatives through lower marginal costs – for instance, Kotze et al (2018) compare virtual teacher training with on-site training and find that with similar effectiveness in terms of learning outcomes, the digital intervention is cheaper and easier to scale.

Thus far, we have stablished that strong partnerships between stakeholders, low marginal costs of intervention methods and appropriate amounts of relevant research are thought to be positive influences on scalability of ETEs. Additionally, there is the question of a trade-off between economies of scale and implementation quality (Crawfurd, 2020; Rodriguez-Segura, 2021), based on the premise that for smaller markets the cost of contextual product tailoring is greater. Consequently, the potential scalability of an intervention is dependent on the size of the market it caters, conditioned on factors like language or curricula. In chapter 4 of this

dissertation I further test these emerging theories, identify other relevant factors and empirically substantiate them.

2.5 Co-existence with mainstream schooling

Interaction and co-existence with formal schooling is a crucial part of EdTech enterprises' work. Even those ETEs that do not rely on schools for implementation, such as Ubongo, see the vast majority of their target learners engaged with the local formal education system in one way or another. One important question arising in this regard is whether EdTech should serve as a substitute or a complement of traditional schooling, which is a question that remains open and under-addressed.

When discussing improvements to instruction interventions particularly, Rodriguez-Segura (2021) notes that further research "could explore whether EdTech is more effective at replacing actual instruction or at reinforcing instruction through tailored exercises "after an actual teacher lecture". Currently, very few studies have empirically tested this relation. Bettinger et al (2020) explore the education production function through a RCT which varied dosage of computer-assisted learning (CAL) as a substitute of traditional learning. Results show that production function is concave, meaning that substituting traditional learning for computer-assisted has diminishing marginal returns. Authors find that while the intervention was effective learning-wise, a doubling of dosage of CAL has led to no observed improvement compared to baseline. These findings suggest that a blended approach would be optimal.

Similarly, a meta-analysis of personalised technology-supported learning in low- and middle-income countries (Major et al., 2021) finds that "personalised technology implementation of moderate duration and intensity had similar positive effects to that of stronger duration and intensity", also suggesting that optimal efficiency, especially when costs are considered, is in moderate amount of technology integration.

Chapter 3: Methodology

3.1 Research design

Preliminary literature review identified that research in the field of educational technology has focused primarily on the consumers rather than the providers of EdTech. Meanwhile, the global educational landscape is increasingly being influenced by the "business-driven companies" (Renz and Hilbig, 2020) – tech giants, small-to-medium enterprises and even startups. Additionally, the established potential of technology to improve learning and proven effectiveness of various intervention techniques (Rodriguez-Segura, 2021) clearly does not

translate directly to real-world implementation and dissemination of EdTech solutions at great scale. Moreover, while some factors contributing to successful implementation and scaling have been theorised (Neiderhauser et al., 2018; Renz and Hilbig, 2020), little is known about those processes still. Thus, I attempt to bridge this gap by investigating how EdTech companies (ETEs) improve learning outcomes in developing countries with technology and what paths they take to sustainable scalability. To do so, I adopt a qualitative case study research design with multiple cases, informed by the methodological structure and recommendations of Robert Yin (2018) and Kathleen Eisenhardt (1989; Eisenhardt and Graebner, 2007).

This design is chosen for a number of reasons. Firstly, the main research question of this dissertation is concerned with "how" and "why", rather than "to what extent", which suggests an explanatory approach best suited by case study method. While I am also interested in questions like "what factors promote implementation and scalability", such "what" questions are exploratory in nature and do not require enumeration, validating a case study approach. Secondly, studying our subject matter (EdTech enterprises) does not require strict control over behavioural events, which would suggest an experimental design (Yin, 2018). Finally, this dissertation studies a set of contemporary events, allowing for the use of a broad range of data sources, including direct observations and interview data, which further supports case study design choice.

Additionally, multiple-case design was preferred to a single-case study, because the research focus is not on describing the existence of a phenomenon under rare or extreme circumstances, but rather on addressing the need for mid-range theory building. Multiple case design is expected to yield more "robust, generalisable and testable theory" (Eisenhardt and Graebner, 2007). Because of this, Chapter 4 presents a relatively brief overview of each individual case, instead concentrating on cross-case analysis.

3.2 Sampling procedure and case selection

"Theoretical sampling" approach (Eisenhardt and Graebner, 2007) was used for case selection. This implies that cases are selected based on their capacity for "illuminating and extending relationships and logic among constructs" in the process of theory-building. In order to build theory from multiple cases, this dissertation uses replication logic (Eisenhardt, 1989), meaning that cases are treated as a string of laboratory experiments to test, contrast and extend emerging theory. However, unlike real laboratory experiments, case studies embrace the rich socio-cultural context that each separate case exists in. Here, each case is an EdTech company (both non-profit and for-profit) operating in developing countries.

Specifically, the inclusion criteria for case selection only supported enterprises that (1) focused on improving learning outcomes and/or quality of education, (2) actively operated in at least one low- to middle-income country (although for the final selection, the majority of the operations was in such countries), (3) involved the use of educational technology and/or

technology-mediated learning as a major source of impact, and (4) targeted secondary school children (although many had broader scope). Additionally, the "polar types" (Eisenhardt and Graebner, 2007) tactic was employed, which involved selecting a differentiated set of cases to improve the validity of theory-building. Indeed, the final selection (Gradely, Open Learning Experience, Ubongo, EnCube Labs and War Child's "Can't Wait to Learn") provides great variability – from the largest EdTech company in Africa (Ubongo) to a young enterprise yet to move cross-boarder (Gradely), from targeting private school children (Gradely) to war-affected youth (Can't Wait To Learn), from providing learning management systems (OLE) to teaching with robotics kits (EnCube). The number of cases (five) was deemed most appropriate as it allows for both significant saturation of cross-case analysis and reasonable thoroughness within the volume of this dissertation.

3.3 Data collection

A combination of primary and secondary data was collected for the purposes of this case study. Analysis leaned on results of semi-structured interviews as realised account of companies' activity and strategy; however, the findings were tested and appended with secondary data where possible.

Primary data

I conducted five semi-structured interviews with studied companies' executives. For each company I interviewed a person occupying a leading role in the organisation – a CEO, a co-founder or a project lead in cases when the initiative is under an umbrella of a larger organisation. This insured that the interviewees had full access to discussed company's information and represented a highly knowledgable standpoint. The resulting selection was highly variable in characteristics such as age, ethnicity, gender and country of residence. Interviews were deemed necessary to generate rich contextualised data on the enterprises' vision of learning and vitally authentic accounts of their activity. Interviews were designed in a semi-structured format[1] to explore topics related to research question and sub-questions, while also permitting the interviewees to raise relevant and insightful points. Table 1 below summarises interview details and provides reference codes.

Date of interview	Enterprise	Reference code
27/06/21	EnCube Labs	[A]
03/07/21	Open Learning Experience	[B]
11/07/21	Can't Wait To Learn	[C]
16/07/21	Ubongo	[D]
17/07/21	Gradely	[E]

Table 1: interview details

[1] Please see appendices for an interview structure overview

Secondary data

Secondary data used for the purposes of this study included published documents, such as annual reports or press-releases, and information on companies' websites, as well as third-party reports and case studies were applicable.

3.4 Limitations

Naturally, delimiting the case study to five enterprises means that certain bias is created through this case selection, as the extent to which the emerging theories are generalisable to the entire body of educational technology enterprises in developing countries is not totally clear. However, I attempted to validate any findings against my broader knowledge of the field and did not report any findings where there was suspicion of weak generalisability. As discussed in section 3.2 the cases were selected to represent a variety of EdTech enterprises based on their countries of operations, size, target communities and intervention methods, in order to ensure greater validity of any emerging theories. Additionally, certain bias can arise through interviewee selection, as all interviews were conducted with representatives of companies' leadership and it is not clear whether evidence gathered from other company employees or stakeholders would fully support the findings. However, with the limited volume of this dissertation the decision was made to only include most knowledgeable actors in order to increase the robustness of gathered evidence. Furthermore, with this level of interviewees' homogeneity the observed variances are expected to increase the precision of mid-range theory-building (Gartner, 1985). Nonetheless, the interviewees still represent a broad range of backgrounds, despite their similar occupation, which is further differentiated through the significant differences between the enterprises they lead.

Chapter 4: Case study findings

This chapter presents the findings of case study research[2], beginning with introductions of each separate case and their background information and following with cross-case analysis separated into organising themes.

4.1 Case introductions

EnCube Labs

EnCube Labs is an education company that employs a mixture of STEM and hands-on learning to "nurture the next generation of innovators and entrepreneurs" (EnCube, 2021),

[2] Please see appendices for a condensed summary of initial interview results

with particular focus on mastering skills, rather than content. They deploy robotics "maker kits" to engage children in unique self-led projects. EnCube's workshops allow learners to master product design, mechanical design, electrical system design, fabrication and coding, with some oversight from peer-mentors. The students also "attract and mentor new members from the school community" to create an "ecosystem" (EnCube, 2021)

EnCube's approach is based on the Zero2Entrepreneur framework developed as a part of a research program at MIT. They operate in 7 different countries, including most prominently India, Malaysia and the US.

Open Learning Experience

OLE is a larger scale organisation that attempts to solve three education-related issues: lack of quality materials, lack of effective teaching and lack of meaningful connection to the rest of the world. OLE presents a bundled solution, which includes a cloud-based repository of teaching materials, a server installed in the targeted community to access the materials with integrated learning management tools, distribution of hardware (handheld devices costing 35 USD) and a range of community engagement measures.

OLE has replicated and adapted their approach in over 100 locations across more than 30 countries (OLE, 2021) including Nepal, Ghana, Kenya, Rwanda, Peru, Mexico, Bulgaria and Guinea. They worked with Syrian refugees in Jordan, Somali refugees in Kenya and village health workers in Uganda.

Can't Wait To Learn

Can't Wait To Learn is an initiative launched by War Child Holland – a charity supporting children and youth in war-affected regions. Can't Wait To Learn (CWTL) adapts a game-based learning approach supplemented by access to technology measures (provision of devices, headphones and styluses) to reach underserved children both in formal schools and in out-of-school setting. CTWL's games are aimed at literacy and numeracy training and their visual design is adapted to cultural context to include elements recognisable by and appealing to local children.

Can't Wait To Learn is currently active in 6 countries – Sudan, Uganda, Jordan, Chad, Lebanon and Bangladesh (Can't Wait To Learn, 2021).

Ubongo

Ubongo is one of the largest EdTech companies globally. Ubongo's core product is a set of educational TV shows aimed at primary and secondary school aged children. It is also broadcasted via radio, mobile apps and online, as well as distributed on USB drives. More recently, the company began engaging with SMS-conveyed measures. They "leverage the

power of entertainment, the reach of mass media and the connectivity of mobile devices" to deliver learning cheaply and at scale (Ubongo, 2021).

Ubongo has reached 24 million households in 40 countries, covering the vast majority of African continent. They create cartoons in 9 different languages – English, French, Kiswahili, Kinyarwanda, Hausa, Kikuyu, Luo, Yoruba & Chichewa.

Gradely

Gradely is a for-profit educational company providing an integrated digital solution for schools (K-12) aimed at raising overall learning efficiency. The package includes educational content (materials and courses), a learning management system, parent materials, assessments and access to personal tutoring.

Gradely is a very young company only founded in the last quarter of 2019. They currently operate exclusively within Nigeria and produce content in English language only, although they have seen a rapid expansion across the country (Gradely, 2021) and are planning scaling into other countries and languages [E].

4.2 Vision of learning

The first topic of this inquiry closely linked to research subquestions 1 ("How is learning envisioned within educational technology enterprises?") and 2 ("What material practices are employed by them to improve learning outcomes?") is the vision of learning, referring to the way that EdTech enterprises conceptualise, measure and deliver learning. Section 4.1 contained an overview of the latter, outlining the solutions to and mechanisms of delivering learning by the studied ETEs.

Most broadly, learning outcomes tend to be measured based on assessments, such as literacy and numeracy tests, which is also true for most of the literature on educational technology interventions (e.g. Major et al., 2021). Indeed, it was established that the use of such metrics is quite prominent in ETEs. For instance, Can't Wait To Learn (CWTL) is utilising national literacy and numeracy assessments and have also developed in-house assessments based on a combination of international standards such as EGRA to have a framework applicable across countries [C]. Ubongo reported the use of metrics such as school readiness scores and MELQO [D], while Gradely, being largely a learning management system provider, relies primarily on standard literacy, numeracy and other assessments [E].

What presents a more interesting finding is the variety of ways in which EdTech enterprises go beyond this standard conceptualisation of learning. Most of the companies (with the only exception of Gradely) prioritise other indicators when it comes to in-house assessment of whether learning was delivered. Many noted the importance of overall well-being and quality of life improvement [B][C][D], as well as positive change in learner's confidence and

aspirations [A]. Additionally, the centrality of mastering the application of a skill rather then memorising content was mentioned often [A][C]. This was reflected in the various metrics that these enterprises gathered. For example, EnCube collected survey data assessing learners' life aspirations changes in a number of timeframes [A]. Data on health, health knowledge, character strengths, as well as social and cognitive skills was also gathered [B][D]. In relation to character strengths measures, efforts were made by Ubongo to de-westernise these metrics and make them more applicable to the range of local contexts they are working in [D]. In particular, they have begun work on developing a metric capturing "*Utu*", which is a Swahili concept that could be translated as humane personality and sensibility. Such measures take time to calibrate and enhance, but represent an exciting development.

What was established is that the broad range of learning measures reflected a variety of applications for which they could be needed. First, there are proof of concept and proof of effectiveness needs. To establish that particular solution is viable it is important to have clear and straightforward metrics which are "meaningful and comparable with other projects" [C], and for these purposes standard literacy and numeracy assessments work best, especially when it comes to large scale randomised trials. Second, there are broader research purposes for which capturing more nuanced information or particular aspects of learning may be necessary. And finally, there are other metrics which are not directly linked to academic outcomes, but which are key to informing the enterprises about how learners experience interacting with a given solution and often are even more important to company's internal evaluation of successfulness of their intervention.

4.3 Implementation and prerequisites

The second topic revolved around the prerequisites for implementation. In other words, under what conditions can the established vision of learning be realised in practice and thus what limitations exist to its implementation. Literature review and prior research have revealed a preliminary list of factors which could be a hinderance to EdTech implementation in developing countries – specifically, lack of connectivity and access to technology, weak governance and cost-effectiveness (Rodriguez-Segura, 2021). Additionally, when studying e-learning implementation in general, Ali et al. (2018) categorise a broad range of barriers to e-learning advancement into (1) individual, (2) pedagogical, (3) technological and (4) enabling conditions. Pedagogical side is discussed in section 4.5, while cost-effectiveness considerations are closely linked to scalability, the focus of section 4.7.

Indeed, access to technology and connectivity limitations were recognised by the interviewees and this recognition is reflected in the work of the studied enterprises. In particular, Ubongo's show relies on children's access to a TV, a radio or a mobile device for distribution. Thus, assessing the level of such access and, perhaps more importantly, identifying effective methods of improving it, were both key avenues of company's research [D]. Specifically, they have started distributing free USB drives pre-loaded with content to

target larger audience and hired a rural distribution coordinator in Kenya to further improve reach [D]. For Gradely, connectivity was a crucial prerequisite to implementation, as integrating their learning management system (LMS) required the target school to have good access to electricity and internet connectivity [E]. However, because their business model implies a subscription fee, only private schools were able to afford it [E], and these schools generally did not face connectivity issues.

For most of the studied ETEs, improving access to technology was a part of their work. Three out of five companies include hardware provision in their package – OLE, CWTL and EnCube. The two former companies supply handheld devices and supplementary electronics (such as servers or headphones) which are used to mediate their educational content, while EnCube's learning model includes setting up workshop labs and providing the "maker kits" [A]. OLE also provides solar power solutions for electricity, and it was reported that such measure is effective [B]. Costs are an important factor when it comes to providing access to technology (Rodriguez-Segura, 2021). Indeed, the design of handheld devices focused on lowering the costs as well as ensuring ease of use [B][C], which is exemplified by OLE's Raspberry Pi tablet, currently costing USD 35 (OLE, 2021).

Very few individual prerequisites were identified by interviewees. In fact, in the case of EnCube its was specified that there are "no individual prerequisites" [A], suggesting primarily that little to none pre-existing skills are required, and that pupils tend to be limited by their own confidence instead, and thus would inevitably succeed with the right support. In the case of Ubongo, it was identified that the age group of 6-9 year-olds may struggle to get the full intended educational benefit from the TV show aimed at secondary school pupils, because it is ahead of them curriculum-wise [D], which is why Ubongo are intending to bridge this gap with a new show aimed at that age group [D]. Certain community characteristics could also have adverse affect on the individual level, such as violence or lack of access to food and water [B], although in the context of this dissertation they are considered under governance. Furthermore, some enterprises focus primarily on communities where such issues are prevalent. Particularly, Can't Wait To Learn was targeting children and youth out of both formal and even non-formal education in Sudan [C] – some of the most marginalised communities, where their solution proved to be effective.

Finally, the significance of governance and political factors was recognised by all interviewees. EnCube representative voiced the need for "leadership believing in change" [A] and similar points were raised by OLE and CWTL [B][C]. Indeed, while these enterprises may wield powerful and proven tools for improving learning, they can hardly put them to use effectively when the target communities are not willing to accept such change, especially when we are talking about implementing overseas. However, such commitment does not have to happen on the government level – it could be communities or particular schools that embrace a given EdTech initiative without needing state approval [A][E]. Nevertheless, productive relationship with the government of the country of implementation seems to be highly important. OLE representative reported that the officials of one state (unspecified) were unwilling to cooperate without prior receiving a bribe [B], which led to a decision not to

expand operations into this country. Another curious example of the influence of political factors came from Ubongo, who experienced problems delivering their content via TV and online around election periods, as availability of broadcast time is greatly reduced and at times internet connectivity is being (potentially purposefully) interrupted [D]. Furthermore, scaling up within a country often required cooperation with government officials [C][D] and a "strategy to convince the government" of intervention's value [B]. This issue is further discussed in section 4.7. Evidence suggests that some entrepreneurs made efforts to minimise the need for interaction with the state officials for convenience purposes [A][E].

4.4 Co-existence with formal schooling

This section is generally asking the question of whether EdTech enterprises are a substitute or a compliment to formal education. Literature review identified that this topic is currently ill-addressed by scholars. Many studies on effectiveness of EdTech interventions do not explicitly test whether results are contingent on the "EdTech portion of the intervention" and not extra practice time, since such interventions tend to be implemented on top of regular schooling (Rodriguez-Segura, 2021). Additionally, studies that have tested this relationship gather evidence suggestive of optimality of a blended approach (Major et al., 2021; Bettinger et al., 2020).

The case study evidence overwhelmingly suggests that ETEs do not view themselves as a substitute of mainstream schooling. All interviewees considered their enterprise a compliment or a supplement to it, and suggested that EdTech and formal education exist in a symbiotic relationship of one form or another. Particularly, EnCube's workshops were considered an "enhancement to what they [schools] currently do" [A]. In this case, the company is looking to see its EdTech classes integrated as a "design and technology" course in the Cambridge schooling system [A], which is an example of how an unorthodox learning method could eventually find its way into formal education. This notion of formal education being a rigid system "stuck in its ways" [B] was common – OLE was described as an agent of "change" that is able to slowly affect the system on an institutional level, rather than replace it [B]. In the discussion of Can't Wait To Learn initiative it was explicitly mentioned that "the last thing we [CWTL] want to do is create a parallel education system" [C]. Indeed, as discussed in the previous section, CWTL was able to step in and supplement the governmentally-provided formal and non-formal education streams in Sudan with a program targeting even more deprived communities, showcasing how EdTech could be deployed as a compliment to formal education and make an impact.

Ubongo and especially Gradely are both examples of how an EdTech initiative is designed as a compliment to the education system. In the case of Ubongo, while a very small share of their viewers may not be in formal education, their content is specifically designed to be aligned with school curriculum and to "supplement" it [D]. The most illustrative example is Gradely, whose learning management system is targeted precisely at improving the existing schools and make their work "more efficient" [E]. Overall, evidence suggests that ETEs

could be seen as a supplement and an enhancement to existing education systems, and at times could represent their more flexible element. There was no evidence to suggest a conflict or clash of interests.

4.5 Role of the educator

The interest in this topic stems particularly from the conceptualisation of learning as technology-mediated [3] (Bower, 2019). As established by Ali et al. (2018), a range of "pedagogical" factors could be a barrier to e-learning implementation. Thus, I investigate what form does the role of an "educator" (Bower, 2019) take in EdTech enterprises, what human resources work is done as a part of these interventions and what problems arise in practice.

Indeed, no studied enterprise has fully excluded the educator from the learning mechanism they employed. Ubongo presents an example of technology-mediated learning with the smallest role of human educators, compared with other studied cases. Because the delivery method is educational TV shows, the overwhelming majority of children engage with it on their own [D]. Educators and content designers are still needed to create and adapt the cartoons; however, virtually no human input occurs at the point of learning. On the contrary, EnCube's and CTWL's models of technology-mediated learning require supplementary educators ("mentors" [A] and "facilitators" [C], respectively) to work directly with learners. Can't Wait To Learn employed facilitators for the purposes like "safeguarding children" and "device maintenance" [C], OLE adapted a similar approach [B]. EnCube's mentors had a more teaching role in the running of workshops, although they were encouraged to "learn together" with the children, providing "inspiration, not information" [A]. This was also described as "a yellow belt teaching a white belt" [A]. Interestingly, it was reported that facilitators in CWTL program sought a more "engaged role" [C] in the learning process and both children and themselves ended up benefitting from this adjustment.

Because the use of mentors presents a potential challenge to scalability, a question arises of where and how to attract the appropriate human resources. The three enterprises dealing with this issue specifically (EnCube, OLE and CWTL) reported that sourcing sufficient number of appropriately qualified facilitators was not a significant barrier to implementation [A][B][C]. Three demographics were identified as good sources of relevant human resources – unemployed youth [A][B], the elderly [B] and refugees (which are often qualified, but are not permitted to go into teaching by the local labour laws)[C]. A prominent practice involved attracting the learners from the program to then adopt the role of mentors [A][B][C] which was also reported to "improve their employability" [A]. This practice of an intervention itself yielding potential human resources for further expansion of the intervention is observed elsewhere in the field of transformative entrepreneurship. For example, it is employed by

[3] Please see section 2.3 for discussion of technology-mediated learning theory

mother2mothers, an organisation that combats mother-child transmission of HIV in South Africa with their mentor-mother model (M2m, 2021).

Finally, Gradely emphasised that building "a strong teacher community" [E] was crucial for implementation and scalability, as the need for creating new educational content grew exponentially and this content had be of a certain level of "granularity" to be deployed in the LMS. They were also among the companies who identified the need for an appropriate renumeration of teachers's work, as this was still the primary way to attract staff [B][E].

Overall, while technology served to replace some of the human inputs into learning in EdTech enterprises, the role of the educator remained rather prominent. Enterprises attempted to minimise the limiting factor of high staff requirements through carefully crafting the mentor/facilitator roles in their delivery model. They also recognised and acted upon the need to support the formal schools' teachers in implementing e-learning solutions with measures like supporting materials and guidance.

4.6 Sustainability

Discussion of sustainability focused on (1) establishing whether studied ETEs were able to sustain change over the long-term in a fixed educational context and (2) what factors influenced the capacity of an intervention to sustain change, both positively and negatively. Out of the five companies, four had experience of long-term implementation in any given setting. OLE's Nepal branch is operational since 2007 [B], Can't Wait To Learn worked in Sudan since 2012 [C], while Ubongo's presence in Tanzania, where it now became a "household name", dates back to 2013 [D].

Interestingly, EnCube Labs first tested very short-term courses, whereby they worked with a school for only two days. While these interventions yielded some immediate results, the change was not sustained in the long-term, as later measurements established [A]. In contrast, five week interventions, while still relatively mild in length, were able to create a "critical mass of people", who were then able to catalyse and sustain change by continuing teaching each other and "building an ecosystem" in their community [A]. Currently, EnCube tends to engage with schools for about a year. Other factors supportive of sustainability identified were "consistent underlying goals and values" [B] and "deepening engagement" [D][E]. Gradely presents an illustrative example of the latter. Their executive reported that the schools where Gradely's presence was already established "wanted to integrate with Gradely more and more" [E]. Specifically, they were interested in adding more courses, shifting their assessment and grading to the platform and running summer school classes through it. This follows the general logic of economies of scale – once the school has incurred the "cost" of integrating a new piece of technology, it is increasing its benefit by further integrating. Overall, the findings also support the theoretical conceptualisation of sustainability as one of the components of scalability (Coburn, 2003).

4.7 Scalability

Literature review summarised in section 2.4 has established that (1) partnerships between stakeholders, (2) low marginal costs of intervention method and (3) availability of research-generated evidence were the factors potentially supporting scalability of EdTech enterprises. Additionally, an emerging theory was identified, suggesting that such companies are likely to scale along national and linguistic borders.

First, the empirical findings of this case study support the claim that establishing productive partnerships with key stakeholders in the education industry is crucial to successful scaling. A large majority of interviewees explicitly identified establishing nation-based partnerships as an important prerequisite to scaling up [B][C][D][E]. Often those partners were educational institutions, such as universities [B], or technological companies aiding with national implementation [D]. Additionally, in most cases, partnerships with governmental bodies, such as the local Ministry of Education, have been necessary to scale up [B][C].

Second, there is evidence from secondary data to support the theory that low marginal costs of intervention facilitate scaling. Indeed, the largest enterprise out of the selection of cases presented (Ubongo), relied on a delivery method (TV show) associated with the lowest marginal cost of adding a new learner. However, enterprises which incorporated a large amount of technology provision (namely OLE and CWTL) have also been able to expand across multiple countries and hundreds of communities (OLE, 2021; CWTL, 2021), despite the much higher marginal costs of a new learner associated with their intervention package. A hypothetical explanation for this discrepancy could be that EdTech enterprises receive financial support from charities, governments and venture capitalists, which may offset higher marginal costs if the effectiveness is present.

Third, the importance of research-based proof of effectiveness for scaling of ETEs is significantly reinforced by the findings of this study. Four out of five executives explicitly referred to “proving impact” [D] and “proving effectiveness” [E] as a major challenge on the path to scaling [B][C]. Proving effectiveness was particularly important, because it influenced the ability of enterprises to build successful partnerships with local governments and other stakeholders, convince leadership on different levels of the possibility of positive change and, importantly, to attract financial support.

Fourth, the hypothesis that EdTech enterprises are likely to scale along national and linguistic borders has generally been confirmed by the evidence gathered. On the side of the already scaled companies, Ubongo has followed this “nations and languages” pattern of scaling, pursuing opportunities within the countries of presence and then expanding into countries which curriculum language is already covered (Ubongo, 2021)[D]. On the other side, Gradely, an example of a young company that is beginning to scale, is also currently adopting the same strategy to scaling up: first, exhaust “opportunities within Nigeria” [E], second, expand into countries with English curricula, and only then add other languages, beginning with French since it opens the largest new market [E].

Overall, the generalised findings of empirical research are suggestive of a major role of scalability in the overall improvement of learning outcomes by EdTech enterprises in developing countries, which is explicated in the next chapter.

Chapter 5: Scalability is King

The present state of technology integration into the education sector of developing countries (Crawfurd, 2020) shows that the availability of effective technology-mediated learning methods and tools (Rodriguez-Segura, 2021) alone is not sufficient for a large-scale adoption of EdTech by these economies. Thus, in order to understand the path to successful improvement of learning outcomes via implementation of those methods at scale, one must study the process by which these innovative approaches are disseminated within and especially across various contexts. EdTech interventions could be implemented both by governments and by private organisations, but, while some states have historically been good at innovation (Mazzucato, 2018), concerns about weak governance (Rodriguez-Segura, 2021) and growing influence of the private businesses on the education market (Renz and Hilbig, 2020) are increasingly suggestive of the key role that private supply (businesses and NGOs) has to play in this process of disseminating educational innovation. Therefore, the capacity to improve learning outcomes in developing countries through technology-mediated learning could be conceptualised as the scalability of ETEs in these contexts.

Furthermore, it was discovered from primary data[4] that EdTech enterprises are building partnerships with the government-affiliated stakeholders in the process of scaling up and play an important role in "persuading the government" [B] and "convincing leadership" [A] at state and other levels of the possibility of improvement and the need for change, acting as a catalyst to both state- and business-driven expansion of educational technology. Thus, this dissertation focused on identifying and assessing factors affecting ETE scalability, as well as testing and developing emerging theories on this process.

While empirical data gathered supports the significance of factors such as proof of effectiveness and low marginal costs of intervention methods to scaling, the assessment of evidence *en masse* hints at particular importance of two categories of factors conducive of scalability – (1) strong implementation partnerships and (2) financing strategy. Other factors still play a role, especially at the earliest stages of ETE establishment, however, it is "easy to create a hotspot somewhere" [B] which is highly effective, but what truly presents a challenge is getting through the "messy middle" [C] – a hypothetical space between the startup-sized, small-scale, experimental, highly innovative, test-of-concept interventions and the hyper-large-scale interventions reaching millions of learners at once (often expensive and

[4] See sections 4.3 and 4.7

even inefficient, such as OLPC), both of which tend to attract funding relatively easily [C]. It is in this setting that the two aforementioned factors are most decisive.

All studied ETEs saw revenue generation as a primary component of their scaling strategy. Out of those, Gradely was the only for-profit company. They charged subscription fees for content access and learning management system integration, although they anticipate a shift to "basic" service coupled with a "premium subscription" [E] for the schools that can afford it. Ubongo runs a mix of pay TV and free TV in different countries, although all their content is licensed for "free non-commercial use" [D]. Regardless, all enterprises relied on attracting external financing – Corporate Social Responsibility funds, grants, charity payments, state investment and venture capital. Thus, even when the company generated revenue internally to support its operations or break even, fundraising was the "ammunition for growth" [E].

Similarly, all enterprises prioritised identifying and forging strong national partnerships in their scaling strategy. The reasons for partnerships included, but were not limited to, technical support with implementation [A][B][C], adaptation of content [C][D], sourcing staff [B][E], acquiring certification [A][B] and cooperating with state officials [B][C][D][E]. No incident of scaling was observed or reported that did not feature the support of a "nation-based partner" [B] of some kind. Furthermore, the two factors (financing and partnerships) are potentially mutually-reinforcing as having strong relationships established with government officials and implementing partners should increase the attractiveness of the enterprise for investors.

It is beyond the scope of this dissertation to quantitatively evaluate the cost-effectiveness of the studied enterprises learning methods. However, cost-effectiveness was, seemingly, a contributor to both of the aforementioned factors conducive of scalability. Cost-effectiveness permits the addition of more learners with the same amount of financing raised and thus increases the enterprises' attractiveness for investors keen on social impact. In a similar fashion, it should improve the enterprise's propensity to forge effective partnerships with governmental bodies and national implementing partners.

This does not suggest, however, that the more cost-effective the intervention is, the better it is for improving learning outcomes. EdTech solutions often compete with traditional pen-and-paper ones (Rodriguez-Segura, 2021), so at the very least, the cost-effectiveness has to be considered in relation to the cost-effectiveness of an alternative (potentially non-technological or non-innovative) solution. This means, that, rather paradoxically, expensive interventions could be cost-effective if they are deployed in a niche that is inaccessible to pen-and-paper (or other) alternatives. For example, implementing CWTL's game-based literacy and numeracy learning solution coupled with device provision is not cost-effective in a generic classroom setting where quality training is provided anyway, but because it is deployed in an environment unaccessible to existing capabilities of the local education system (such as war-affected regions of Sudan) it now presents a very attractive solution both in terms of social impact and cost-effectiveness.

Finally, another important takeaway from this study's findings is the reaffirmation of what hereby is referred to as the country-language scaling principle for ETEs, previously hypothesised by some researchers in the field (Crawfurd, 2020). The country-language principle of scaling (illustrated in Figure 3 below) suggests that educational technology enterprises prioritise scaling opportunities in the following way: first, the opportunities within the country of operation are exhausted; then, the enterprise pursues opportunities to expand into countries with the same language of the national curricula; and finally, the enterprise is looking to add new languages, and the principle continues iterating.

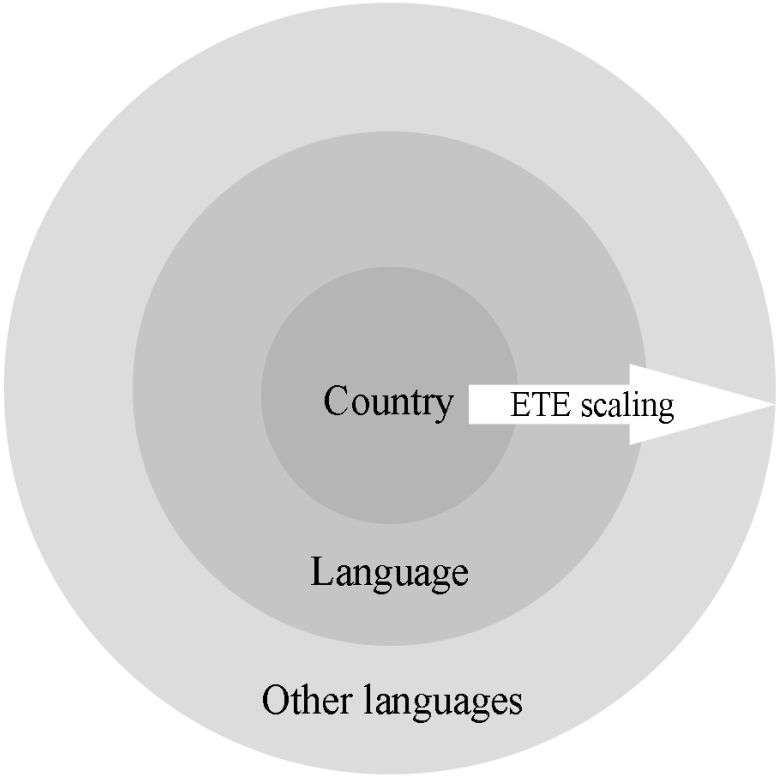

Figure 3: visual representation of the country-language scaling principle for ETEs

The hypothesised reasons behind the principle, supported by the gathered data, are two-fold. First, the enterprise is not incentivised to scale across national borders, as it incurs extra costs from having to adapt its operations to new legal frameworks, educational systems and curricula. Second, the enterprise is not incentivised to expand into new linguistic areas, as it incurs the high cost of adapting their learning materials and content for the new language and are faced with a trade-off between contextualisation and growth. As discussed in section 4.7, all studied enterprises' scaling strategies conform to the principle. This principle suggests that learners living in communities speaking languages less popular than other languages in their geography, as well as learners from countries with weaker presence of educational technology, are likely to be at a disadvantage in access to EdTech interventions, particularly those disseminated by private enterprises. The extent to which governmental distributors of EdTech innovation adhere to the principle remains an open question.

Chapter 6: Conclusion

In this dissertation, I attempted to advance and empirically substantiate academic knowledge on improving learning outcomes in developing countries through close examination of the private supply side of EdTech provision, which is increasingly influential on the global education market (Renz and Hilbig, 2020). I have gathered primary data through semi-structured interviews with executives of five ETEs, representative of the educational technology enterprises in developing countries and conducted qualitative analysis to test emerging theories on the vision of learning that these ETEs adopt, the prerequisites for implementation of their intervention methods, the role of human educator in those enterprises, ETEs' coexistence with formal education and, most importantly, the process of ETE sustaining change and scaling up.

It was discovered that the scalability of educational technology enterprises plays an important role in improving learning outcomes in developing countries. The dissertation assessed the significance of technological, political and individual barriers to implementation of ETE learning solutions and described the ways in which ETEs overcome them. Additionally, the reasons behind the use of different measures of learning were identified and described. This dissertation also addressed an emerging question of co-existence of EdTech with formal education and discovered that ETEs position themselves as a supplement to formal schooling, suggesting a symbiotic relationship with no significant clash of interests. Furthermore, the role of human educator in the implementation of technology-mediated learning methods by ETEs was evaluated.

Most importantly, this dissertation tested the emerging hypotheses on factors conducive of ETE scalability – low marginal costs, extensive research and stakeholder relationships. The findings suggest that two factor categories – strong partnerships and financing – were crucial to successful scaling of ETEs and thus the improvement of learning outcomes in developing countries. Moreover, this research discovered and formulated the country-language scaling principle of EdTech enterprises, discussed in Chapter 5.

This work opens many new avenues for future academic research. For instance, it would be useful to quantitatively evaluate the extent to which different features of ETEs affect their ability to raise financing, assess in what ways they forge implementation partnerships and test the country-language scaling principle thoroughly on a hyper-large scale.

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Appendices

Appendix A: semi-structured interview topics

1. How is learning envisioned? Measured? Delivered?
2. What are prerequisites for implementation? Technological? Financial? Institutional? Political? Other?
3. How does the initiative fit within mainstream schooling? Substitute? Compliment?
4. Technology-mediated learning – role of educators, agency of technology
5. Limiting factors in implementation, bottlenecks
6. Sustainability
7. Scalability snd scaling strategy

Appendix B: summary of interview results (condensed)

	EnCube	OLE	CWTL	Ubongo	Gradely
Method and use of technology	Maker kits Product design Focus on application	Handheld devices, LMS, server, community engagement	Game-based literacy and numeracy learning, hardware provision	TV show, additionally radio, online SMS-services	LMS,, content, assessments, tutoring, parent materials
Measuring learning	Surveys assessing change in life aspirations and confidence	Research-based Quality of life	In-house assessments based on EGRA Trials at scale	School readiness Character strengths MELQO	Assessment-based analysis
Prerequisites	No individual prerequisites Leadership believing in change Resources, mentors	Culture that supports learning, low violence, decent governance, access to water and food	Solution implemented towards target audiences even outside non-formal education	Availability of TV/radio or mobile devices could be an issue	Connectivity School funds to afford subscription services

Co-existence with mainstream schooling	An "enhancement" to schooling	Symbiotic	Assisting existing education to "fill gaps"	"Supplementary education"	Improving effectiveness of existing schooling
Role of educator	Mentors are catalyst, providing inspiration, not information "Yellow belt teaching a white belt"	Need for financial incentives Both elderly and youth – a source of educators	Facilitators Safeguarding Device maintenance Discovered the need for a more engaged role	Engagement with school teachers to help integrate content into classes	Huge role Building a teacher community Technology alone not sufficient
Sustainability	Critical mass of people needed to create an ecosystem	Nepal 2007 – now Consistent underlying goals and values	Sudan 2012 – now	Tanzania 2013 – now Support in adapting content locally	Adding new features and adapting to the needs of schools
Scalability	Need for CSR funds and grants Replicating leadership	Nation-based partners Cooperating with local governments	Challenging to get through "messy middle" Nation-wide partners	Languages Proving impact Revenue generation Distribution coordinators	Scaling along language and curriculum Financing Teacher communities