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Educational Technology in Resource-Constrained Environments

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1.0 INTRODUCTION

Education is critical and fundamental to socio-economic development, because it is the medium through which knowledge, skill and social norms are transferred from one person to another, and from one generation to another. In their paper, Education: Meaning, definition & types, Aman V. et al (2023) state that "education involves the transmission of knowledge, values, and skills from one generation to another, ensuring the continuity and advancement of civilizations". They further suggest that "it goes beyond formal schooling, extending to informal and non-formal learning experiences". Such transfer of knowledge matters for sustainable economic development, trade and social well being within and across communities.

Studies have shown a causal relationship between education and economic development especially in developing countries. Ibrahim Abubakarr Bah (2023) posits that education does not just have higher returns for low and middle income countries, its returns outweigh that of high-income countries. There have also been studies showing that education impacts other aspects of well being beyond the economy. For instance, an individual who can read will better understand the instructions in a health manual and take appropriate steps.

Undisputably, education empowers people to make more informed decisions, relate better and eventually translate to better living.

The concept of education dates back to pre-historic times and the era of non-written communication, where social norms, values and skills were transferred orally or by observation. As writing, dramatisation and other forms of knowledge transfer evolved, the technology for delivering education also evolved.
However, over the past half century, education has greatly evolved along with the media for delivering it. The advent and growth of digital communications technology has significantly reshaped how education is delivered and distributed.

Across all levels of formal and informal education, digital technology now plays a significant role. From children learning nursery rhymes on YouTube to adults learning how to write code from Massive Online Open Coursewares (MOOCs), the delivery of education has been democratised and now almost available to everyone.

In the developing world education technology has presented an opportunity for learners to access learning resources which they otherwise would not have been able to access. However a range of systemic challenges exist which still limit the uptake of EdTech solutions.

Indeed, resource-constrained environments require fundamentally different EdTech architectures that can accelerate uptake and create more economic opportunities for learners. This paper attempts to uncover the challenges that exist and propose the emergence of new EdTech solutions that would drive development at scale in these countries.

2.0 UNDERSTANDING THE EDTECH CONSTRAINT LANDSCAPE IN DEVELOPING COUNTIES

Between 2005 to 2014, the One Laptop per Child (OLPC) campaign sought to transform education by distributing XO laptops to children in developing countries such as Uruguay, Peru, India, Rwanda, Ethiopia, Afghanistan, etc (Shah, n.d). Consistent with many other research works, Santiago et.al (2025) found that there was no impact of no positive effects on schools over time or student educational trajectories. This campaign has become a classic model in the failure of education technology interventions to deliver transformation in learning for developing countries.

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2.1 EdTech Constraints Beyond Developing Countries

While we typically consider developing countries as the primal examples of resource constrained environments, the reality is that several regions in the developed world also fall within this bracket. Regions such as Appalachia, where the regional council reports that there is a rural-urban 'digital divide', Detroit and Flint in the United States, as well as some parts of Northern England and some parts of Wales also face similar infrastructural gaps and economic challenges that affect developing countries. Therefore, the same issues persist with EdTech deployment in these regions.

Bridging the gaps that make the deployment of Educational Technology tools non-effective or less effective is critical in accelerating educational outcomes and facilitating the networking gains that come from technology.

2.2 Infrastructural Challenges

The challenge with Educational Technology in these resource constrained regions is not solely with the technology in itself, rather, it is a mix of factors ranging from infrastructural challenges to content challenges such as;

2.2.1 Electrical Power

Electrical power is a foundational prerequisite that largely determines whether and how educational technologies can be used in learning environments and by learners, EdTech solutions require electric power to operate (Ndlovu, 2024). Areas without stable power see much lower rates of EdTech adoption because devices go unused, online platforms cannot be accessed reliably, and both teachers and students are deterred from integrating digital tools into education. The challenge lies in the fact that regions of the world which need access to electricity to power up education and the economy, are the ones who lack it most.

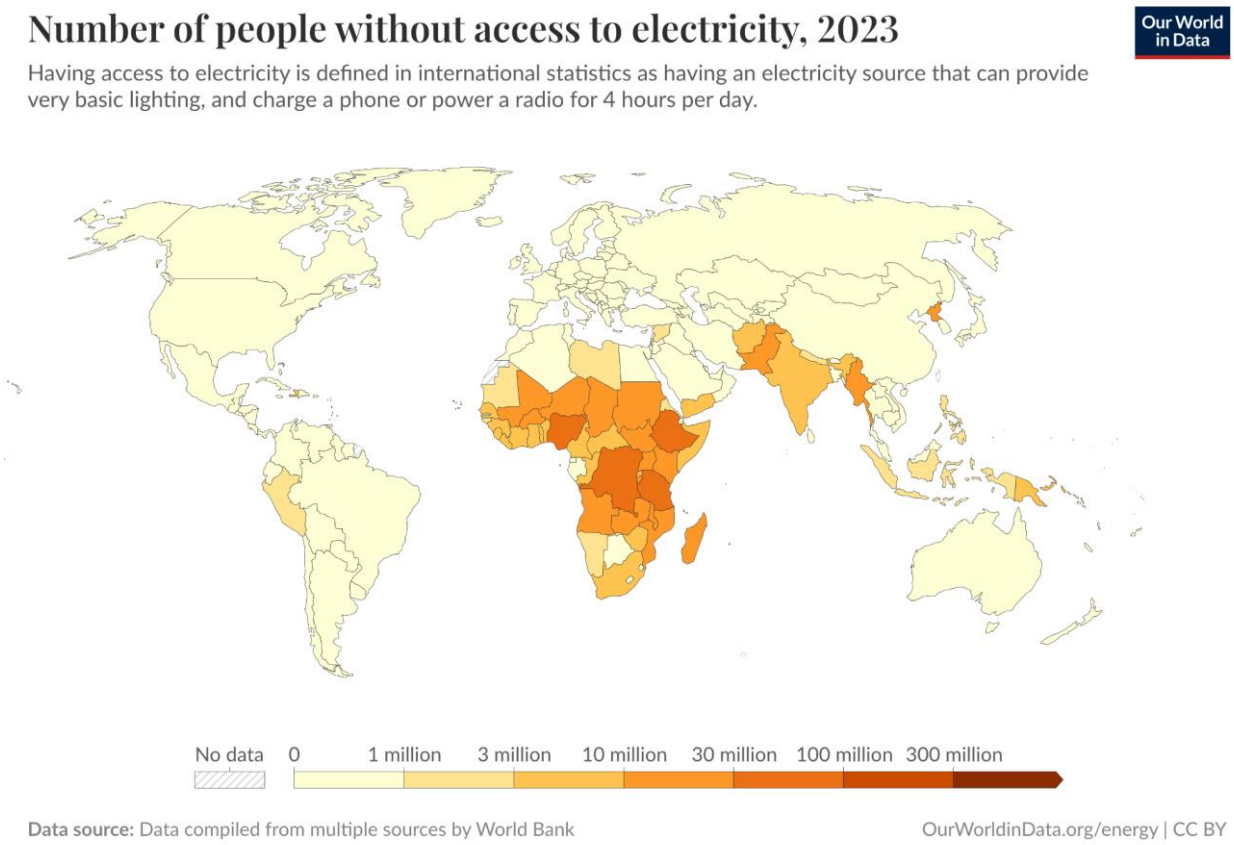

Image Source: Our World in Data

Beyond that, electricity is also required by internet providers to power their infrastructure. Power is critical for use during the process of teaching and learning when using EdTech (Fenton and Joice, 2017). More than any other singular factor, electricity determines

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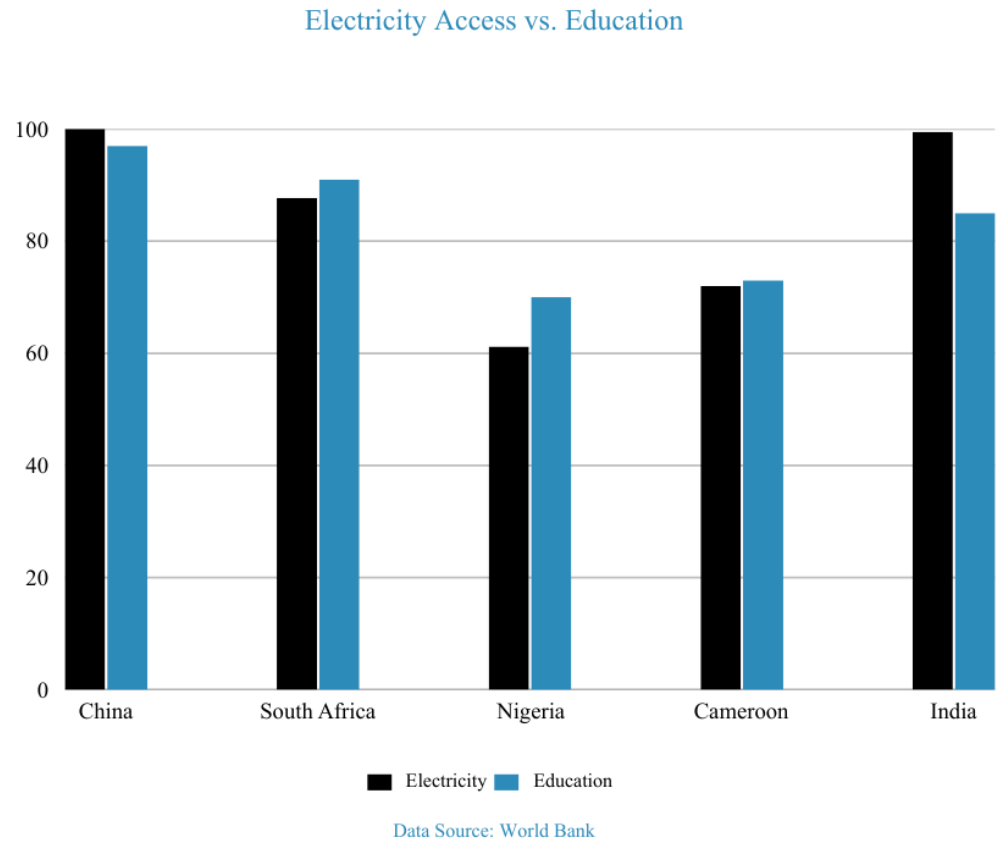
if and when a student can use their devices to access information on the internet. In addition to this, Buying et.al (2022) finds that reliable electricity is associated with high school enrolment and completion.



The data above shows how tightly linked electricity is with education across countries.

2.2.2 Connectivity Challenges

Lack of internet access and high cost of data bundles and technology devices (Ndlovu, 2024) often limit the adoption of EdTech solutions. A key challenge in developing countries is that of Internet bandwidth and coverage, which remains low in many cases. According to the United Nations Office for Digital and Emerging Technologies, the least developed countries are also the least connected.

The paradox then lies in the fact that these countries which require internet access to leapfrog educational outcomes, grow their human capital and bolster economic growth, are also the ones which lack access to reliable internet connectivity. Given that many EdTech platforms and solutions use video for educational instruction, this increases the cost of access and reduces the amount of people who can access the knowledge.

2.3 Economic Challenges

Although data from IntelPoint shows that it costs only $0.38 per mb to access the internet in Nigeria, which is 15 times less than the cost in the United States. When this cost is measured against the adjusted net income per capita, the difference disappears totally. As of 2021, the adjusted net income per capita for Nigeria was at $1,663 which is about 35 times less than that of the United States.

Combined with poverty and the dire economic challenges like recession that plague developing countries, it becomes increasingly difficult to purchase the data required for online learning or the utilisation of education technology.

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2.4 Content Challenges

Many of the EdTech solutions that exist have been built in and for a different context, hence in many situations. In many cases, language barriers fuelled by low literacy levels pose a significant barrier to learning.

Another major barrier comes from the original educational context that the EdTech solution was designed for. Learners outside of that context would struggle to connect with the learning material or apply it within their environment. This is particularly true in many resource-constrained environments where application is done by proxy or simply taught theoretically.

3.0 DESIGNING FOR RESOURCE CONSTRAINED ENVIRONMENTS

As seen above, many of the critical challenges that plague resource constrained environments are systemic and institutional. Problems such as poverty, network access and electricity are not ones that EdTech companies can easily take on by themselves. This then calls for strategic rethinking of the technology and formats being utilised in the delivery and distribution of educational content. A redesign of the current EdTech solutions is required so that they can scale even in resource constrained regions.

By building for resource constrained regions, the EdTech solutions can be tough enough to thrive in worst-case scenarios. This gives the advantage that these solutions can thrive even more in resource-rich regions, leading to a win-win scenario where everyone benefits.

3.1 Addressing Content Challenges

3.1.1 The Low Cost Model

One of the critical innovations required is the building of EdTech solutions that require less bandwidth and hence consume less data. Adapting and compressing instructional material to text-only formats or audio formats or including transcripts can be extremely valuable to users in resource-constrained regions.

Additionally, enabling offline access to core learning materials and quizzes is critical in accelerating access.

3.1.2 The Hub-and-Spoke Model

This is particularly valuable in Vocational Education, where there can be a central online learning hub for theoretical content and physical hub location for practical course content. This significantly reduces the amount of electricity and internet access required to achieve learning outcomes. An example in practice is in TAFE Queensland, Australia, where specialised training is centralised in hubs while extending access to students through smaller, digitally equipped campuses (spokes).

3.1.3 The Skills to Employment Model

In 2016, Google launched Google Digital Skills for Africa, by November 1st 2016, the program had reached 500,000 learners. Today, the program trained millions of learners across Africa teaching them digital skills and showing the opportunities that existed.

One of the key drivers for the success of the Google Digital Skills program was that it leveraged the skills to employment model. By linking learning outcomes to economic opportunities, they maintained learner enthusiasm. In addition to this, course content was also bite-sized, often requiring less internet bandwidth.

3.1.4 The Hybrid Approach

EdTech solutions do not have to be the sole instructional material. By introducing in-person support or community integration, digital technology can serve as an amplifier of human instruction. In their paper, Yánez et.al find statistically significant improvements in academic achievement and student satisfaction among hybrid learners.

3.2 Addressing Systemic Challenges

In addition to remodelling the instructional content and delivery methodology, projects have to be designed to become sustainable over a long period of time. Hence to a considerable extent, the systemic challenges that impact EdTech outcomes need to be addressed. Some low-hanging fruit approaches to this may include:

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3.2.1 Solar Powered e-Learning Hubs

Communities or EdTech platforms themselves can design e-learning hubs within communities or regions to improve access to electricity and foster learning. These hubs could also serve as co-creation hubs.

3.2.2 Network Redesign

Edge computing and adaptive streaming can help reduce bandwidth requirements of content download or consumption. On a larger level, communities can design connectivity solutions such as mesh networking to improve internet access.

4.0 CASE STUDY: MIKE DENNY INTERNATIONAL INSTITUTE OF EXCELLENCE, CAMEROON

The Mike Denny International Institute of Excellence (MDIIE) is a poignant example of integrating educational technology within a resource-constrained landscape like Cameroon where the school is located. The school has four sections; nursery, primary, secondary and high school and has sustained enrollment growth across all grade levels. Between 2015-2024, the Nursery and primary section attained a 54.1% average annual enrolment growth, while the secondary and high school section attained a 42.5% average annual enrollment growth within the same period (MDIIE, 2025). This data demonstrates strong demand due to the school's quality.

The institute prioritises digital literacy and modern pedagogical tools, using it to bridge the significant technological gap facing Central African students. They provide both the Cameroonian national curriculum and internationally accredited American and Canadian programs through our strategic partnership with Flexi Academy Institute (Florida, USA).

This case study analyses the strategies MDIIE utilises to deliver cutting edge education that leverages digital technology.

4.1 Foundational Computer Literacy Programs

The institute focuses on building student proficiency in basic and advanced digital tools right from foundational education phases. This equips students with the requisite skill to adopt and adapt to diverse forms of digital and emerging technologies.

4.2 Prioritising Teacher Training

The impact of technology in education is only as effective as the educators using it, as the teacher is the gatekeeper to the classroom (Omobola et.al, 2014). MDIIE focuses on continuous professional development which is essential in resource-poor areas.

4.3 Blended Learning and Offline-First Solution

For resource constrained regions like Cameroon where MDIIE is domiciled, a blended/hybrid learning approach is a vital driver of scale. In addition to this, leveraging software that functions without internet connection or with limited internet requirement is a driver for scale.

5.0 CONCLUSION

Scarcity fuels innovation. Innovating EdTech solutions to fit the context of resource constrained communities does not just bolster inclusion, it activates innovation from learners. As learners begin to apply their knowledge, they drive economic development, and a virtuous cycle is born.

However, at this infancy stage of economic development, low resource and low cost platforms remain the best platforms for delivering education in resource constrained communities. It is hence imperative that EdTech founders, policy makers, and the community lean into the massive opportunities that educational technology offers and leverage it to shape a better future for all.

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