OPPORTUNITY
EduFinance

How to
DESIGN EFFECTIVE EDTECH SOLUTIONS

Lessons from Existing Research

March 2024

How to
DESIGN EFFECTIVE EDTECH SOLUTIONS
Lessons from Existing Research

March 2024

What are the necessary design considerations for education technology to improve student learning outcomes?

The use of education technology (EdTech) has been steadily increasing in recent years, from low-tech solutions through WhatsApp and radio to high-tech software installed on laptops in classrooms. In February 2021, the EduQuality program of Opportunity EduFinance launched a new blended learning professional development program. Participating school leaders and teacher mentors receive a low-cost tablet loaded with a learning management system application developed by Chalkboard Education hosting customized EduQuality content. This blended approach to professional development offers school leaders and teachers a combination of in-person training alongside digital content, including EduQuality's resource libraries, self-access quizzes, digital guides, and tools.

In the years since its launch, EduQuality has sought to ground its blended learning approach in best practices and lessons learned from other programs in other contexts. However, despite the growth

> "No one can deny the importance of technology, and the COVID-19 pandemic demonstrated why online education should be a vital part of teaching and learning. However, educational technology has some challenges as many teachers don't have enough knowledge on the use of technology."[1]
>
> **— Frederick Kabagema**
> School Leader, Little Starts Daycare Center, Uganda.

---

[1] https://edufinance.org/latest/blog/2021/the-new-eduquality-blended-learning-model-launch-life-changing-to-the-children-in-our-schools

of EdTech in recent years, results are mixed on how EdTech solutions can most effectively complement traditional learning approaches to improve learning outcomes. This evidence brief sets out to answer these critical questions on EdTech in low- and middle-income countries (LMICs). What can we learn from existing research on successful EdTech solutions? What makes these programs effective, and how can these lessons be applied in practice? How can EduQuality ensure it effectively integrates its blended learning solutions for school leaders and teacher mentors to ultimately improve student learning outcomes?

EdTech is a broad term that refers to the application of any electrically-powered technology (hardware and software) in education, with the goal of improving teacher pedagogy and student learning (Rodriguez-Segura, 2020). This includes, but is not limited to, the distribution of hardware (such as laptops or tablets) to students and teachers for educational purposes, the use of specialized educational software or content on existing devices, or the adaptation of existing technology such as TV, radio, or SMS messaging for education (Rodriguez-Segura, 2020).

In most cases in LMICs, these EdTech solutions are implemented alongside traditional learning materials and are used as a complementary tool – either by teachers in classrooms, or by students at home to supplement in-school material. Multiple studies and systematic reviews have shown that the provision of technological

and hardware inputs alone is not enough to significantly increase learning outcomes (Tauson & Stannard 2018; GEAAP, 2020, Conn, 2017; Beuermann et al., 2015; Mouza & Cavalier 2012; Passey 2016; Piper et al. 2015). As such, many EdTech practitioners have attempted to integrate EdTech into existing education approaches and accompany hardware provision with additional activities (Beg et al., 2019; Rodriguez-Segura, 2020). Despite some success, the evidence surrounding EdTech is mixed, and many studies reach different conclusions about what must accompany EdTech to have an impact.[2] This evidence brief reviews the vast literature on EdTech in LMICs to synthesize the common factors and conditions necessary for EdTech programs to improve learning outcomes for disadvantaged students. It identifies three conditions that are necessary for EdTech interventions to achieve success, and considers the implications for applying these findings to policy and practice:

1. **Consider existing access** (including *gendered* access) to technology to ensure learning outcomes are equitable and cost effective.

2. **Employ personalized-adaptive learning** software to deliver individualized instruction.

3. Accompany EdTech with **ongoing teacher training** to integrate technology in the classroom.

---

[2] Many EdTech programs are offered after school hours, and it is therefore difficult for researchers to understand whether positive learning outcomes were achieved because of the software alone, or from the additional instructional time. As such, this evidence brief emphasizes studies of EdTech programs that are implemented during school hours

1. Consider existing access (including gendered access) to technology to ensure learning outcomes are equitable and cost effective

Multiple studies conclude that while EdTech can be a powerful tool, it is not necessarily more effective or cost efficient in improving learning outcomes than traditional approaches (Evans & Acosta, 2020; Ma et al., 2020; Major et al., 2021). Further, there is a risk that EdTech may exacerbate inequalities rather than combatting them if it is not thoughtfully designed (Rodriguez-Segura, 2020). Access to technology both at home and within the classroom – alongside the cost of facilitating greater access – are important factors to consider at the design phase of any EdTech intervention (Rodriguez-Segura, 2020).

The COVID-19 pandemic exposed inequities in technological access and highlighted the challenges faced when relying on technology for equitable remote schooling (Vegas, 2020). However, even when EdTech is used within the classroom for in-person teaching, whether a student has access to technology *at home* can affect their confidence to engage with the technology at school.

This is a particular challenge for female students. As one study cautions, **"if the gender dynamics are not considered, the use of EdTech carries the risk of heightening gender disparity within education in LMICs"** (Steeves & Kwami, 2017: p.184). Webb et al. (2020) outlines that, due to pervasive gender biases in the household, female students often have less access to technology outside the classroom, which can impede their confidence in engaging with technology within the classroom. Teachers may also exhibit biases about female students' technological capacities or exacerbate stereotypes that female students do not enjoy working with technology as much as their male counterparts (Webb et al, 2020; Meno, 2012; Pitchford et al., 2019). These considerations must be acknowledged at the outset and carefully built into the design of any EdTech intervention – for example, by allowing students to take their devices home, or by building in after-school programs to accompany in-school programs (Malamud and Pop-Eleches 2011, Mensch and Haberland, 2018). Webb et al. (2020) also highlights the importance of gender awareness teacher training that includes components on the inclusive use

of EdTech and gender-responsive teaching (Webb et al.,2020; Okudi, 2016).

Lastly, access to electricity that enables digital infrastructures and internet access in public classrooms is necessary to ensure the uptake of Edtech solutions. The level of digital integration in education varies greatly depending on the context, and this alone may determine whether EdTech is the most cost-effective method for improving learning outcomes. In countries such as India, Kenya, and South Africa, national policies have called for significant investments in digital infrastructure in public classrooms (Piper et al., 2015; Sharma, 2021; Kozma and Surya Vota, 2014). In these contexts, many classrooms already have access to devices with sufficient connectivity, so software-based programs that utilize existing hardware are highly cost effective (Muralidharan et al. 2019; Rodriguez-Segura, 2020). In other contexts, even the most basic ICT penetration is limited. For example, in Cambodia, Nepal, and Myanmar, less than 10% of all primary schools have access to electricity (UNESCO), and in Sri Lanka, Kyrgyzstan, and Bangladesh, less than 10% of all schools have access to the internet (UNESCO).

In other contexts, high ratios of students sharing one device – on average 500 students per computer in Niger and Zambia (Rodriguez-Segura, 2020) – may result in
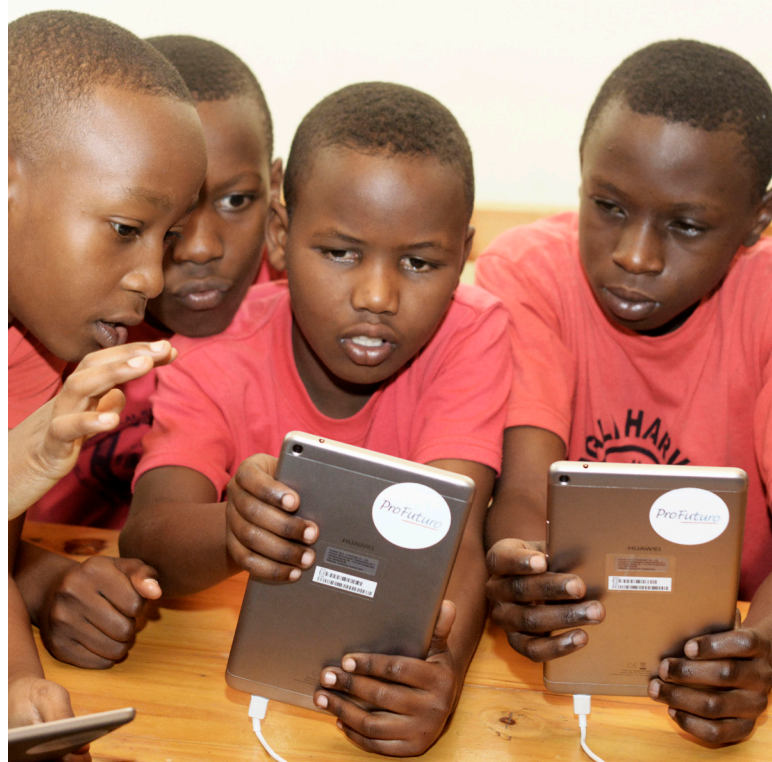
more limited impacts on learning outcomes when students cannot engage with the technology for a sustained length of time each day. Procuring hardware to ensure classrooms have enough devices may have high costs that outweigh any added benefits of using the software. In contexts without widespread ICT coverage, EdTech interventions may be financially inaccessible to scale and limited connectivity may present barriers to expansion (Rodriguez-Segura, 2020). In those cases, it may be worth considering **whether EdTech is the most cost effective, equitable solution when compared to more traditional learning approaches.**

Implications for policy and practice

Policymakers and practitioners must weigh the risks and benefits of EdTech utilization and consider several factors to understand whether a specific EdTech program is effective and equitable. Given the limited funding available for education in many resource-constrained environments, it is also essential to consider whether EdTech is *cost-effective* and equitable compared to traditional learning approaches. Striking a balance between cost-effectiveness and equity of EdTech intervention is crucial because interventions characterized as cost-effective may exclude marginalized learners in resource-constrained environment (Chuang, et al 2021).

When considering whether to employ EdTech solutions to achieve equitable educational outcomes, policymakers and practitioners may consider the following:

- Are national education policies supportive of technology in classrooms?

- What is the current level and dependability of internet and electricity in targeted classrooms?

- What is the current level and dependability of ICT and digital infrastructure in targeted classrooms, including remote areas?

- Will additional investments and procurements be required?

- Are additional investments in hardware cost effective? Would traditional approaches and/or other pedagogical interventions achieve similar learning outcomes at lower costs?

- What ratio of students per device is necessary for EdTech to have a positive impact on learning outcomes?

- Do students have equal access to technology at home?

- Are accompanying after-school programs necessary to ensure outcomes are equitable?

- What additional support is necessary for students without at-home access to technology?

- Has any additional gender sensitivity training been integrated for teachers?

- To what extent does evidence suggest a given solution or program is effective?

- To what extent does the solution support students with disabilities?

## 2. Employ personalized-adaptive learning (PAL) software to deliver individualized instruction

Multiple studies have found that adaptive learning and teaching at the right level (with or without technology) can have a significant impact on improving learning outcomes, particularly for students falling behind their grade level (Banerjee et al. 2017; GEAAP, 2020; Conn, 2017). However, in traditional classroom settings, offering personalized and adaptive instruction places a heavy burden on the teacher, who is required to individually assess the level of each student and quickly adapt their teaching to each need (Glewwe and Muralidharan 2015).

As such, many studies have shown that PAL software that adapts its lessons for student levels can be one of the most effective uses of EdTech (Major

& Francis, 2020, Ganimian & Murnane, 2014, Kremer et al, 2013; Conn, 2017; Angrist et al. 2020b; Tauson & Stannard, 2018; McEwan 2015). Computer software can provide individualized instruction through artificial intelligence that "learns" the level of the user and seamlessly tailors the content it offers (Andallaza et al., 2012). For example, Ito et al. (2019) conducted a randomized control trial on an adaptive learning software in Cambodia and found it significantly increased math test scores compared to the control group. The study argues this was in large part due to the adaptive nature of the software – not only because it alleviates the burden on the teacher to individually adapt lessons, but also because content that is appropriately tailored to learning levels keeps the student engaged for longer periods of time. Other examples of adaptive learning software have demonstrated similar results,[3] including in India (Muralidharan et al., 2019; Hirshleifer, 2016 – see case study on page 5), Kenya (Piper et al., 2015), and El Salvador (Buchel et al, 2019).

In contexts with little connectivity or with limited access to hardware such as laptops and tablets, it is important to consider low-tech adaptive learning solutions that take advantage of pre-grouped students by learning level. For example, during COVID-19, one program in Botswana used SMS messages to deliver weekly math problems combined with phone calls to answer questions (Angrist et al. 2020). The math questions were tailored to student learning levels, and a randomized control trial found it significantly improved test scores particularly for students that were falling behind. However, critical to this success was the fact that Botswana had already began a country-wide scale-up of the Teaching at the Right Level (TARL) policy, in which students are grouped by learning level rather than by age, allowing the low-tech program to easily tailor the math problems to student learning levels. Without this TARL policy in place, the SMS program may not have been as successful.

---
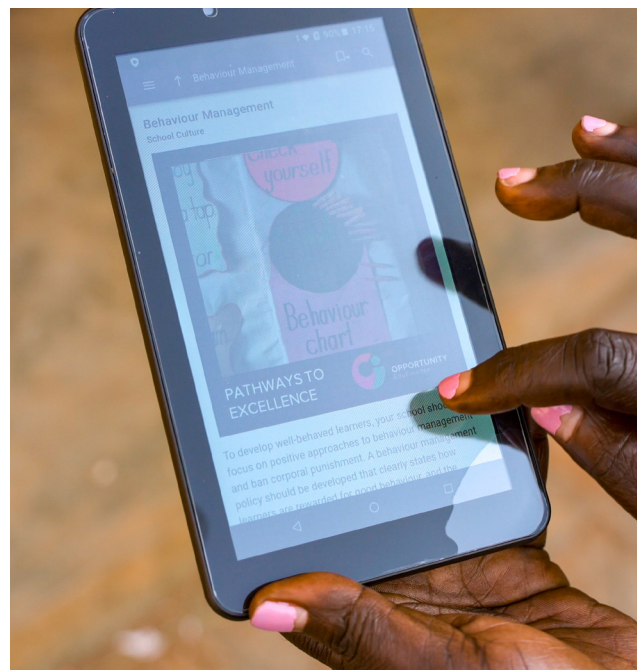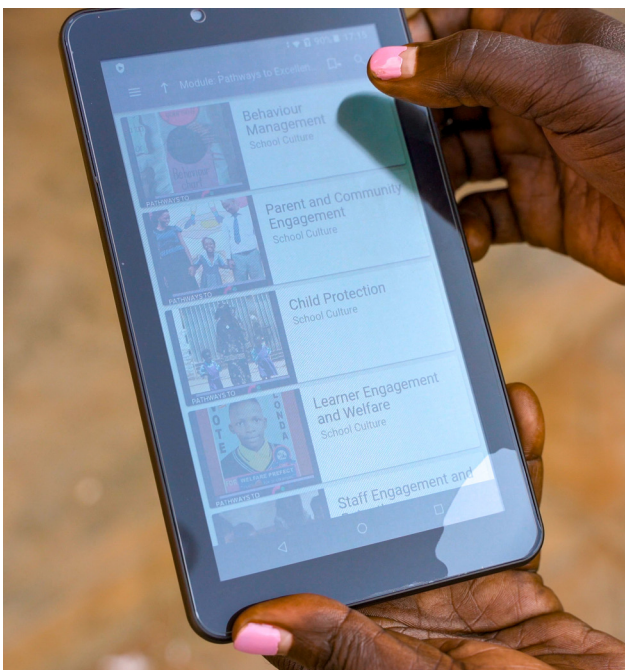
[3] Specific adaptive learning software applications include *ThinkThink!* (Ito et al. 2019), *MindSpark* (Muralidharan et al., 2019), *Khan Academy* (Buchel et al, 2019; Hirshleifer, 2016), *Papaya and Tangerine:Class* (Piper et al., 2015)

Implications for policy and practice

▶ **Adaptive learning is not a panacea.** Stakeholders and practitioners funding and implementing EdTech should consider the learning potential of using an adaptive learning software versus a static software without AI capabilities. However, despite its effectiveness, impact on learning outcomes can vary depending on various factors such as student learning needs (Major et al, 2021). Equally, AI-driven systems are also susceptible to perpetuating existing inequalities such as those based on language, gender, and ethnicity (Alrawashdeh, 2022). As such, stakeholders should ensure adaptive learning algorithms are carefully designed and tested to ensure that they are free from bias and safeguard student privacy. Establishing and using ethical guidelines in the selection of PAL systems can help stakeholders in choosing appropriate solutions.

▶ **Consider existing digital infrastructure:** Practitioners should consider that employing adaptive learning software may be most cost effective when used in contexts where national governments have already made ICT investments in public school classrooms. EdTech for adaptive learning may have the greatest impact in countries with national policies that have called for investments in digital infrastructure in public education, such as Kenya (Piper et al., 2015) and India (Sharma, 2021).

3. Accompany EdTech with ongoing teacher training to integrate technology in the classroom

Another widely cited factor affecting the success of EdTech interventions is the teacher's ability to appropriately integrate the use of technology with the rest of the curriculum. Numerous studies have shown that there is no impact on student learning outcomes when technology replaces rather than complements the teacher (Major & Francis 2020; Gambari et al., 2016a; 2016b;

Muralidharan et al., 2019). Further, studies have shown that learning gains are greater when the technological interventions are delivered by an experienced teacher rather than by a supervisor who administers the technology but does not offer pedagogical support (Buchel et al. 2020). As one systematic review of EdTech interventions in the Middle East and North Africa region

---

[4] Opportunity EduFinance, 2023. *Pathways to Excellence: Assessing EduQuality school progress in quality improvements.* https://edufinance.org/publications/research-and-learning/pathways-to-excellence-assessing-eduquality-school-progress-in-quality-improvements/.

stated, **"ICT can replace teachers and organized learning only in rare instances; but it can provide effective support to education, especially when supplemented with teacher training"** (Lewis and Thacker, 2016: 1).

However, the mere presence of a teacher will not improve outcomes if the teacher is not equipped with the necessary skills and attitudes to successfully integrate technology into their classroom. Therefore, teacher professional development is a critical investment that must accompany any successful EdTech intervention. One comparative study on the One Laptop Per Child program in three different contexts found that the level of training and support provided to teachers greatly influenced the program's impact on learning outcomes (Warshchauer et al. 2014).

Further, studies have found that the **teacher training should be an ongoing activity**, rather than a single introductory training (Dahya, 2016). In a study of an EdTech intervention in Kenya, Piper et al. (2015) finds that when teachers were provided ongoing coaching in how to integrate the tablets in their classrooms, their students performed significantly better than those with teachers that received a one-off training at the start of the intervention. As Passey et al. (2016) and Tauson & Stannard (2018) both highlight, teachers need time to adjust to the new teaching methods that inevitably accompany new technologies, and continued coaching is essential in supporting teachers as they adapt and learn.

Lastly, Tauson & Stannard (2018), Mouza and Cavaliar (2012), and Barrera-Osorio and Linden (2009) emphasize the importance of training that **goes far beyond generic how-to instructions** on using the technology. Rather, the content of the training should be closely aligned with the curriculum structure, student needs, and pedagogical methods already in place, and focus on how to integrate the technology within these existing practices. Programs that do not prioritize teacher training to this standard often fail to see significant impacts on learning outcomes. For example, Barrera-Osorio and Linden (2009) studied a program that provided computers and teacher training to schools in Colombia. However, the generic nature of the teacher training was not enough for teachers to truly grasp the benefits of the technology, and they struggled to fully integrate it to positively impact learning outcomes. Barrera-Osorio and Linden (2009) emphasize the need for thorough training that is tailored to teachers' needs and real-world experiences in the classroom, without which teachers may struggle to understand how technology can support them and their students.

Implications for policy and practice

▶ **Emphasize the role of the teacher:** Stakeholders must recognize the critical role of the teacher for EdTech interventions to be effective. While many have championed EdTech as a scalable solution for improving *access* for students in remote locations, this may not result in improved *learning outcomes*. While "low-tech" EdTech (e.g., via television or radio) can be used to reach students who would otherwise not have access to any form of schooling, improving *learning outcomes* for existing students through EdTech alone is unlikely without the support of a dedicated teacher (Ganimian et al. 2020).

▶ **Consult with teachers directly to understand their experience with EdTech:** In a recent Policy Insights paper, Anand (2022) emphasizes that "Listening to teachers' voices can help us identify loopholes in the online education system and point us towards new pathways forward" (NORRAG, 2022; Anand, 2022, page

11). Involving teachers in the design of trainings and co-creating modules with them is an important step that can help increase the efficacy of trainings.

▶ **Plan for ongoing teacher training:** To be most effective, teacher training must be ongoing and provide continuous support as teachers gradually adapt and learn new methods. The need for continuous teacher training to accompany EdTech interventions has cost implications, as these programs are likely to require ongoing costs rather than one-off costs that are easier to scale.

▶ **Devote resources to teacher training:** Stakeholders should prioritize interventions that combine a model of ongoing teacher training and coaching alongside EdTech implementation, as the evidence shows this has a greater impact on learning outcomes for disadvantaged learners.

▶ **Incorporate gender sensitivity training:** As outlined above, gender biases within the household can translate into female students engaging less with technology in the classroom (Webb et al., 2020). Stakeholders should prioritize teacher training that includes gender considerations, in addition to considering ways to reduce girls' barriers to accessing technology outside of the classroom so they are not at a continual disadvantage.

Research in Practice: *How Does EduQuality Apply Lessons from Research to Program Design?*

As the first cohort of EduQuality's blended learning professional development program wraps up the third year since its launch, it is an opportune moment for the program to reflect on and incorporate additional lessons from research into its existing activities and future planning. EduQuality is in the process of conducting an assessment of its blended learning approach, alongside continued analysis of research on EdTech globally. Initial reflections illustrate how EduQuality is already incorporating the above design considerations, while also looking forward to how to improve on other areas:

▶ **Accompany EdTech with ongoing school leader and teacher training:** The blended learning approach relies on school leaders and teacher mentors being able to access and use the learning management system app on the distributed tablets. As such, it is critical that school leaders and teachers not only understand how to use the technology, but also the value of the technology. The EduQuality program strives to support school leaders and teachers with these concepts through introductory seminars, ongoing training sessions, and annual visits carried out by Education Specialists. During these sessions, leaders are presented with an overview of the blended learning model components and how it can benefit their school as a sustainable, quality educational institution.

▶ **Use data to ensure EdTech is appropriately integrated:** The current learning management system allows for the collection, centralization and analysis of large volumes of participant data to inform and optimize the impact of the program. This immediately-available data is essential to informing rapid program adjustments, and ensuring the program is adapted to meet school leaders' and teachers' needs. Alongside this data, after the blended learning approach was rolled out in 2021, it was necessary to have the right tool to measure the changes in actual teaching practices in the classroom: how are teachers engaging learners as they integrate evidence based teaching strategies into their classrooms? Therefore, the Monitoring and Evaluation team developed and launched a bespoke Classroom Observation tool, which gathers data on changes in classroom teaching practices, student engagement, and classroom environment at our partner schools over time.
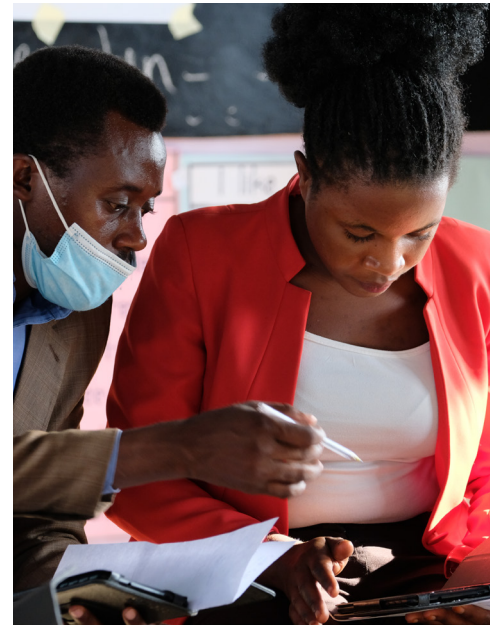
Looking Ahead

▶ **Consider gendered access to technology:** EduQuality is actively encouraging more female participation in the program. In many contexts, school leadership is a male-dominated profession, and as a result, there are fewer female school leaders who participate in leadership training programs. As EduQuality encourages more female participation in the future, it is critical that our blended learning model also considers how female school leaders may have more limited prior access or experience with technology, and may require additional support to ensure equity and inclusion within the program. Further, it is essential that M&E tools, such as the Classroom Observation tool discussed above, also consider gender in data collection by disaggregating male and female responses, and integrating gender-specific questions within surveys. Ensuring a gender-sensitive approach to training in technology, alongside a gender analysis of data and feedback, is critical to ensuring equitable access to technology.

▶ **Tailor technology to local contexts and capacities:** Lastly, as the EduQuality blended learning professional development program continues to expand, it must be tailored to local contexts. This must consider areas that have limited connectivity, and the existing infrastructure within a context. As a first step, the current learning management system app contains an offline function, which ensures the content is accessible and data can be saved even without an internet connection. However, one key ongoing challenge is access to reliable connectivity and electricity in remote areas to charge devices and periodically transmit data. In addition to challenges with internet connectivity, it is also critical to consider the existing capacity of school leaders and teachers to use technology, which may differ significantly depending on context. The program aims to place significant emphasis on enhancing the digital literacy skills of teachers and school leaders to enable them to overcome technical obstacles and gain the confidence to utilize technology. Looking forward, it is important the program consider how challenges might differ depending on context, and design adaptations and improvements accordingly.

For more information on EduQuality's blended learning professional development program, visit: https://edufinance.org/latest/blog/2021/partnering-for-scale-opportunity-edufinance-and-chalkboard-education-launch-a-blended-learning-model-that-supports-school-resiliency

REFERENCES

Andallaza, T. C. S., Rodrigo, M. M. T., Lagud, M. C. V., Jimenez, R. J. M., & Sugay, J. O. (2012). Modeling the Affective States of Students Using an Intelligent Tutoring System for Algebra. Proceedings of The Third International Workshop on Empathic Computing (IWEC).

Alrawashdeh, G. S. (2022). Approaches to Technology-enabled Personalized and Adaptive Learning: A Brief Overview. https://doi.org/10.31219/osf.io/5jeyh

Angrist, N., Peter Bergman, Caton Brewster, and Moitshepi Matsheng. (2020a). Stemming Learning Loss During the Pandemic: A Rapid Randomized Trial of a Low-Tech Intervention in Botswana. CSAE Working Paper WPS/2020¬13. *Centre for the Study of African Economies, University of Oxford*. Accessed: https://www.povertyactionlab.org/sites/default/files/research-paper/working-paper_8778_Stemming-Learning-Loss-Pandemic_Botswana_Aug2020.pdf

Angrist, N., Evans, D. K., Filmer, D., Glennerster, R., Rogers, F. H., & Sabarwal, S. (2020b). How to Improve Education Outcomes Most Efficiently? A Comparison of 150 Interventions using the New Learning-Adjusted Years of Schooling Metric. The World Bank. https://doi.org/10.1596/1813-9450-9450. Available from http://elibrary.worldbank.org/doi/book/10.1596/1813-9450-9450. (details)

Banerjee, A., Shawn Cole, Esther Duflo, Leigh Linden. (2007). "Remedying Education: Evidence from Two Randomized Experiments in India," *The Quarterly Journal of Economics*, MIT Press, vol. 122(3), pages 1235-1264, 08.

Banerjee, A., Rukmini Banerji, James Berry, Esther Duflo, Harini Kannan, Shobhini Mukerji, Marc Shotland, Michael Walton. (2017). From Proof of Concept to Scalable Policies: Challenges and Solutions, with an Application. *Journal of Economic Perspectives, American Economic Association*, vol. 31(4), pages 73-102.

Barrera-Osorio, Felipe, and Leigh L. Linden. (2009). The Use and Misuse of Computers in Education: Evidence From a Randomized Controlled Trial of a Language Arts Program. Cambridge, MA: *Abdul Latif Jameel Poverty Action Lab (JPAL).*

Beg, S., Adrienne M. Lucas, Waqas Halim, Umar Saif. (2019). Engaging Teachers with Technology Increased Achievement, Bypassing Teachers Did Not. Working Paper 25704 National Bureau of Economic Reesarch. http://www.nber.org/papers/w25704.

Beuermann, Diether W., Julian Cristia, Santiago Cueto, Ofer Malamud, and Yyannu Cruz-Aguayo. (2015). One Laptop Per Child at Home: Short-Term Impacts from a Randomized Experiment in Peru. *American Economic Journal: Applied Economics* 7 (2): 53-80.

Buchel, K., Jakob, M., Kuhnhanss, C., Steffen, D., & Brunetti, A. (2020). The Relative Effectiveness of Teachers and Learning Software. Evidence from a Field Experiment in El Salvador. Working Paper No. 2006, Department of Economics, University of Bern. URL: www.vwi.unibe.ch

Buchel, K., Martina Jakob, Christoph Kuhnhanss, Daniel Steffen and Aymo Brunetti. (2019). Expanding school time and the value of Computer-Assisted Learning. (El Salvador, *Consciente).*

Chuang, R., Burnett, N., Robinson, E. (2021). Cost-effectiveness and EdTech: Considerations and case studies. (Helpdesk Response 32). EdTech Hub. https://doi.org/10.5281/zenodo.5213890.

Chatterjee, A., Kothari, P. (2017). 'Bridging Achievement Gaps Amongst School Students through a Technology-based Blended Learning Model'. *Educational Initiatives Pvt. Ltd.* Available from: https://www.researchgate.net/publication/282929326_Bridging_achievement_gaps_amongst_school_students_through_a_technology-based_blended_learning_model.

Cimini, T., Morgan, S., Rahman, B., Raposo, J. (2020). Fostering Learning: Driving Improvements in learning Outcomes for Children in Low-resources Communities. Toronto: Opportunity International. Accessed from: https://edufinance.org/publications/research-and-learning/fostering-learning-driving-improvements-in-learning-outcomes/

Conn, K. M. (2017). Identifying Effective Education Interventions in Sub-Saharan Africa: A Meta-Analysis of Impact Evaluations. Review of Educational Research, 87(5), 863–898. https://doi.org/10.3102/0034654317712025

Cummings, C., & O'Neil, T. (2015) Do digital information and communications technologies increase the voice and influence of women and girls? A Rapid Review of the evidence *Overseas Development Institute*.

Dahya, N. (2016). Education in Conflict and Crisis: How Can Technology Make a Difference? A Landscape Review. *INEE*

Evans, D. and Popova, A. (2015). What really works to improve learning in developing countries? an analysis of divergent findings in systematic reviews. Published by Oxford University Press on behalf of the World Bank. https://openknowledge.worldbank.org/handle/10986/29308

Ferreira, F. (2017). Reaching the Unreached Through Open and Distance Learning (ODL) in Bangladesh, India and Pakistan. *Commonwealth of Learning*. http://hdl.handle.net/11599/2757

Gambari, I. A., Gbodi, B. E., Olakanmi, E. U., & Abalaka, E. N. (2016a). Promoting Intrinsic and Extrinsic Motivation among Chemistry Students using Computer-Assisted Instruction. *Contemporary Educational Technology*, 7(1), 25–46. https://doi.org/10/ggv6gc

Gambari, A. I., Shittu, A. T., Falode, O. C., & Adegunna, A. D. (2016b). Effects of computer-self interactive package (CSIP) on students' performance, achievement level and attitude toward mathematics at secondary school in Nigeria. *Al-hikma Journal of Education*, 3(1), 14.

Ganimian, A. Emiliana Vegas, and Frederick M. Hess. (2020). Realizing the Promise: How can education technology improve learning for all. Brookings. Accessed: https://www.brookings.edu/essay/realizing-the-promise-how-can-education-technology-improve-learning-for-all/

Ganimian, A. and Richard J. Murnane. (2015). Improving Education in Developing Countries: Lessons From Rigorous Impact Evaluations. Review of Educational Research. 86: 3, page(s): 719-755 https://doi.org/10.3102/0034654315627499

Glewwe, P., and K. Muralidharan. (2015). Improving School Education Outcomes in Developing Countries: Evidence, Knowledge Gaps, and Policy Implications. Working Paper RISE-WP-15/001. *University of Oxford, Research on Improving Systems of Education (RISE), Oxford*.

Glewwe, P., E. A. Hanushek, S. D. Humpage, and R. Ravina. 2014. "School Resources and Educational Outcomes in Developing Countries: A Review of the Literature from 1990 to 2010. In P. Glewwe, ed., Education Policy in Developing Countries. Chicago and London: University of Chicago Press.

Global Education Evidence Advisory Panel. (2020). "Cost-Effective Approaches to Improve Global Learning." World Bank and UK's Foreign, Commonwealth & Development Office. https://www.edu-links.org/index.php/resources/cost-effective-approaches-improve-global-learning

Hirshleifer, S. R. (2016). Incentives for Effort or Outputs ? A Field Experiment to Improve Student Performance What incentive contracts are most effective at motivating effort in order to improve outcomes? 1-45.

Ito H., Kasia K. & Nakamuro M. (2019). "Does Computer-aided Instruction Improve Children's Cognitive and Non-cognitive Skills?: Evidence from Cambodia."

Kremer, Michael, Conner Brannen & Rachel Glennerster. (2013). The Challenge of Education and Learning in the Developing World. *Science*, 340, 297-299

Kozma, R.B., & Surya Vota, W. (2014). ICT in developing countries: policies, implementation, and impact. J.M. Spector et al. (eds.), Handbook of Research on Educational Communications and Technology, 885 DOI 10.1007/978-1-4614-3185-5_72

Lewis, K. & Thacker, S. (2016). ICT and the Education of Refugees: A Stocktaking of Innovative Approaches in the MENA Region. World Bank Education, Technology & Innovation: SABER-ICT Technical Paper Series (#17). Washington, DC: The World Bank. Available at: http://saber.worldbank.org

Ma, Y., Fairlie, R. W., Loyalka, P., & Rozelle, S. (2020). Isolating the "Tech" from EdTech: Experimental evidence on computer assisted learning in China (No. w26953). National Bureau of Economic Research. https://doi.org/10.3386/w26953

Malamud, O., & Pop-Eleches, C. (2011). Home computer use and the development of human capital. The Quarterly Journal of Economics, 126, 987–1027.

Malamud, O., Cueto, S., Cristia, J., & Beuermann, D. W. (2019). Do children benefit from internet access? Experimental evidence from Peru. Journal of Development Economics, 138, 41–56. https://doi.org/10.1016/j.jdeveco.2018.11.005

Major, L. & Francis, G. A., and Tsapali, M. (2021). The effectiveness of technology-supported personalised learning in low- and middle-income countries: A meta-analysis. *British Journal of Educational Technology*, 2021:52, 1935-1964. DOI: 10.1111/bjet.13116

Major, L. & Francis, G. A. (2020). Technology-supported personalised learning: Rapid Evidence Review. *EdTechHub*. 10.5281/zenodo.3948175

Major, L., Francis, G. A., & Tsapali, M. (2021). The effectiveness of technology-supported personalised learning in low- and middle-income Understanding the Potential of Using EdTech to Measure and Mitigate Learning Losses 48 EdTech Hub countries: A meta-analysis. British Journal of Educational Technology, n/a(n/a). https://doi.org/10.1111/bjet.13116. Available from https://bera-journals.onlinelibrary.wiley.com/doi/abs/10.1111/bjet.13116. (details)

McEwan, P. (2015). Improving Learning in Primary Schools of Developing Countries: A Meta-Analysis of Randomized Experiments. *Review of Educational Research* 85: 353–94.

Mensch, B., & Haberland, N. (2018). GirlsRead! Zambia DREAMS Innovation. ISRCTN. https://www.popcouncil.org/uploads/pdfs/2018PGY_GirlsRead_Brief.pdf

Meno, Y. J. S. M. (2012). Gender bias in attitude towards girls in the Use of computers in selected schools in central Africa. Journal of Continuing, Open and Distance Education, 1.

Mouza, C., & Cavalier, A. (2013). Emerging Technologies for the Classroom, The Role of One-to-One Computing in the Education of at-Risk High-School Students p.145-159.

Muralidharan, K., Singh A. & Ganimian A. J. (2019). Disrupting Education? Experimental Evidence on Technology-Aided Instruction in India. *American Economic Review*, 109(4): 1426–60. DOI: 10.1257/aer.20171112

NORRAG. (2022). Policy Insights #01: The Digitalisation of Education. Accessed: https://resources.norrag.org/resource/719/the-digitalisation-of-education

Okudi, C. (2016). State capacities and challenges in educating women and girls: The Ugandan experience. *Buwa!* 7: 53–58.

Passey, D., Laferrière, T., Ahmad, Y.-A., Bhowmik, M., Gross, D., Price, J., Shonfeld, M. (2016). Educational Digital Technologies in Developing Countries Challenge Third Party Providers, 19(3), 121–133.

Piper, B., Jepkemei, E., Kwayumba, D., & Kibukho, K. (2015). Kenya's ICT Policy in Practice : The Effectiveness of Tablets and E-readers in Improving Student Outcomes. *Forum for International Research in Education*, 2(1), 3–18.

Piper, B., & Kwayumba, D. (2014). The Primary Math and Reading Initiative ICT intervention. Endline report. Prepared under the USAID Education Data for Decision Making (EdData II) project, Task Order No. AID-623-M-11-00001 (RTI Task 13). Research Triangle Park, NC: RTI International.

Piper, B., Jepkemei, E., & Kibukho, K. (2015). Pro-poor PRIMR: Improving early literacy skills for children from low-income families in Kenya. *Africa Education Review*, 12(1).

Pitchford, N. J., Chigeda, A., & Hubber, P. J. (2019). Interactive apps prevent gender discrepancies in early-grade mathematics in a low-income country in sub-Saharan Africa. *Developmental Science*, 22(5), e12864. https://doi.org/10/gf62gt

Rajendran, R., Muralidharan, A. (2013). 'Impact of Mindspark's Adaptive Logic on Student Learning'. *IEEE Fifth International Conference on Technology for Education*. Available from: https://www.researchgate.net/publication/271551280_Impact_of_Mindspark's_Adaptive_Logic_on_Student_Learning

Rodriguez-Segura, D. (2020). Educational technology in developing countries: A systematic review. EdPolicyWorks working paper. Accessed: https://www.curry.virginia.edu/sites/default/files/uploads/epw/72_Edtech_in_Developing_Countries.pdf

Sharma, A. (2021). Impact of ICT on Teaching Practices in India. ICT India Project Working Paper #46. *Center for Sustainable Development, Columbia University*. Accessed: https://csd.columbia.edu/sites/default/files/content/docs/ICT%20India/Papers/ICT_India_Working_Paper_46.pdf

Steeves, H. L., & Kwami, J. (2017). Interrogating gender divides in technology for education and development: The case of the One Laptop per Child Project in Ghana. Studies in *Comparative International Development*, 52(2), 174–192. https://doi.org/10.1007/s12116-017-9245-y

Tauson, m., & Stannard, L. (2018). Edtech For Learning in Emergencies and Displaced Settings: A Rigorous Review and Narrative Synthesis. *Save The Children*. https://resourcecentre.savethechildren.net/node/13238/pdf/edtech-learnin g.pdf

Vegas, E. (2020). School closures, government responses, and learning inequality around the world during COVID-19. The Brookings Institution. https://www.brookings.edu/research/school-closures-government-responses-and-learning-inequality-around-the-world-during-covid-19/

Warschauer, M., Zheng, B., Niiya, M., Cotten, S., & Farkas, G. (2014). Balancing the One-To-One Equation: Equity and Access in Three Laptop Programs. *Equity & Excellence in Education*, 47(1), 46–62.

Warschauer, M., & Ames, M. (2010). Can One Laptop Per Child Save the World's Poor? *Journal of International Affairs*, 64(1), 33–51.

Webb, D., Katie Barringer, Rebecca Torrance, and Joel Mitchell. (2020). *Girls' Education: A Rapid Evidence Review*. EdTechHub. https://doi.org/10.5281/zenodo.4737460. Available at: https://docs.edtechhub.org/lib/CZBRW85R. Available under: Creative Commons Attribution 4.0 International.

UNESCO Institute for Statistics: Proportion of schools with electricity and telephone communication facilities, 2012.

UNESCO Institute for Statistics: Proportion of educational institutions with Internet access, by type, (primary and secondary) 2012.

UNESCO Institute for Statistics: Learner-to-computer ratios (primary and secondary), 2012.

OPPORTUNITY
EduFinance

Visit us at
edufinance.org

Learn about Opportunity's
global work at
opportunity.org