Education inequality in underserved regions: Exploring the role of technology to promote diversity and inclusivity

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***Abstract*—In underserved regions, the educational inequality gap between better-served children and under-served children is wide. At the same time, the digital inequality gap in such countries is narrowing; less endowed families are now able to access some digital technologies. Therefore, there is the need to use technologies for educational purposes to support less-endowed children in promoting diversity and inclusivity. This research is explorative research to highlight issues in the use of technologies for education, such as adoption, barriers, challenges and benefits in African context. In doing so, we seek to promote diversity and inclusivity for education in underserved regions and bridge the education inequality gap. This research will contribute to academic research relating to inclusivity to support under-served children in developing countries. It will push forward educational technology research and contribute to policymaking. The outcome of this research would prepare the foundation for a future large-scale implementation across Sub-Saharan Africa.**

Keywords—Educational inequality gap, Diversity, Technology Acceptance, Technology Adoption, Technology Discrimination

I. INTRODUCTION

As Nelson Mandela said, "Education is the most powerful weapon we can use to change the world". Unfortunately, education inequality (especially in developing countries) is crippling global efforts to change the world through education. The recent global pandemic has worsened education inequality [1]. For example, before COVID, over 66% of children in Ghana were multidimensionally poor, during COVID, over nine million learners could not access their education and vulnerable learners had their education curtailed [2]. On the other hand, the world has seen an explosion in the use of digital devices (e.g., mobile phones and the internet) over the past two decades [3]. Developing countries are no exception – recently, Ghana had the highest mobile phone penetration in West Africa with a mobile adoption of over 55% which is higher than the regional average of 44.8% [4]. With the decreasing cost of purchasing and maintaining a digital device and internet connection, more families, including the less-served, now own a digital device with an internet connection. Ghana's mobile subscriber penetration was projected to reach 67% in 2020 [5]. With a strong call for African nations to extend broadband coverage to rural/remote areas, this trend is set to continue upwards [6]. The advance in technology and high adoption rate means that there is room to improve how technology is applied and have a greater impact. We do this in this research in the educational sector and considering the African context.

In the past few decades, researchers have been investigating how digital technology could be used to improve the learning outcomes of students – especially students in remote and/or low-income communities [7], [8]. The World Bank has committed to this agenda and has been investing state-of-the-art educational technologies in middle and low-income countries. Any Educational Technology for Remote Communities (EdTech-RC) - especially in developing countries - must predominantly operate offline since such communities cannot afford consistent internet access. Even though many EdTech-RC have been proposed, it is rare to find one that provides a bespoke pedagogical framework for underserved children and leverages the children's accessible technologies for large-scale implementation.

In line with this, this paper aims to answer the question: "What are the challenges in the use of technologies for educational diversity and inclusion of children in undeserved regions?"

To answer this question, the objectives of this research paper are:

1. To highlight the barriers/challenges to technology acceptance and adoption for education by children in underserved regions.
2. To present an understanding of educational technology and its impact on the educational development of children in underserved regions.
3. To propose solutions for educational technology adoption and the effectiveness of appropriate accessible technologies for children in underserved regions.

II. BACKGROUND

Digital technology has permeated every facet of life, including education, and it is fast becoming indispensable in the delivery of quality education. However, due to the prevalent and stark education inequality in developing countries [9], children from underserved regions are

marginalised with little hope of better academic outcomes [10]. Better-served children are in a privileged position to attain higher educational achievements due to the public education subsidies available to them [11]; the situation has worsened since the onset of Covid [12], [13]. Various technological and educational efforts have been made to address this [14]. Such interventions are not panaceas in themselves, but they shape how education should be delivered to bridge the education inequality gap [15]. The authors provide a background of these interventions under the known categorisations [16] below.

A. Access to Technology

One of the notable interventions aimed at providing access to educational technology is the "One-laptop-per-child" (OLPC) scheme that has been rolled out across various countries. Research conducted in Colombia on OLPC using a two-year randomised experiment on over 5000 children reveal that OLPC schemes that do incorporate only computers into the educational process have a very minimal effect[17]. Similar research has been conducted in Peru, Uruguay, Brazil and Costa Rica and the results have been similar – OLPC schemes alone do not improve the scholarly outcomes of children although they improve "digital skills" [16]. Other technology-access-only interventions implemented in Israel, Romania and other parts of the world find similar results; only a few research endeavours have marginally positive outcomes[16]. However, "access to technology" interventions that have seen some appreciable benefits are those that have focused on providing high-level and large-scale technological implementations[16]. It is evident that access to education is necessary for improving the outcomes of learners but it is not sufficient in doing the same – more peripheral schemes must accompany access to education. Access to technology is not only a necessary step to education but also a crucial step for inclusivity and equality.

B. Technology – enabled Behavioural Inteventions

Technological interventions aimed at improving learners' outcomes by changing the behaviour of teachers, and parents of the learners exist. Such systems are important because, in developing countries, challenges such as teacher absenteeism, difficulty in keeping classes engaged, and low rates of teachers' instructional on-task time are prevalent [16]. Indirect, physical technological interventions such as in-class cameras and social accountability mechanisms aimed at improving teachers' behaviour can be effective[18]. Such technologies must have a very low barrier to implementation and usage for them to be effective[16]. Interventions that are most successful in the technology-enabled behavioural category (targeted at various stakeholders – teachers, learners and parents) are those which incorporate some level of accountability, and collaboration between the stakeholders and have a low barrier to usage; such systems are also scalable and relatively inexpensive [16] and they are designed to be intuitive and to promote engagement.

C. Improvements to Instructions

Improvement to instruction is instruction-centric interventions that aim to improve the quality of tutor instructions (including remote instruction, in-person instruction and remote engagement with parents and tutors) to improve learning outcomes even if the instructions are phone-based to parents to support their wards [19]. In regions where rural areas fail to attract and retain qualified trained teachers, remote instruction could prove helpful [16], [20]. In-person instructions where tutor efforts are enhanced using technology are also fruitful [16], [21]. Finally, remote coaching interventions that connect tutors to parents in supporting learners could be effective in improving learning outcomes [22]. For such systems to be effective, it is expedient that they are designed to be accessible by both tutors and/or parents cost-effectively and engagingly.

D. Self-led Learning

Self-led technological interventions provide a personalised learning experience where learners can learn at their own pace and level with limited supervision or tutor support [16], [23]. Self-led technologies are software-centric, unlike access to technology interventions that are predominantly hardware-centric. Such software-based interventions can be effective [24]. Other effective interventions are those with learner-engagement and rewards features such as accessibility [25], gamification [26] and adaptability [23] – the ability to adapt the difficulty of lessons to learner needs. Evidently, self-led learning interventions are effective when specific features are embedded in them and the learners are given the flexibility to study at their own pace[16].

In summary, EdTech can be a powerful force for good in developing countries [16] but if it is not carefully implemented, it could be ineffective [27] or have a very negative impact on learners[28]. Stakeholders would want EdTech to be a great enabler [29] that minimised the education inequality gap which manifests in terms of inclusivity, diversity, equality and equity. From the above discussion, successful EdTech implementations must be accessible (hardware and software), must promote self-learning (which promotes diversity, equity and equality) and must be inclusive (not only to the learners but to their tutors and parents where possible).

III. Methodology and Data

This study adopts an exploratory research method, which is a simplified qualitative case study research approach. The concepts of diversity and inclusivity are deeply explored in connection with the role of technology for enhancing education equality particularly for underserved regions in Ghana. Data used for exploratory analysis are extracted from several sources such as OECD's Programme for International Student Assessment (PISA), World Bank Development Indicators, Trends in International Mathematics and Science Study (TIMSS), U.S. Agency for International Development (USAID), National Education Association (NEA) amongst others.

Using the exploratory research approach, several facets of education inequality in underserved regions are highlighted [30], and a case for inclusivity and diversity of education resource is made. To demonstrate the trend of education inequality in Ghana, bar charts, graphs, and histograms are used to demonstrate the paucity of access to education and how technology can be used to bridge the gap between interested stakeholders (private, government, international organizations) and the regions that are education deficit.

IV. Analysis and Discussion

Learning assessments provide data on the status of learning, which can be used to monitor the quality of systems and student learning outcomes [31], [32]. Regular monitoring can reveal changes over time in response to interventions to improve student outcomes, providing feedback and additional data for decision-making [33]. Learning data, in conjunction with other dimensions of quality such as context, teaching and learning environment, and learner characteristics can reveal the factors that most affect learning outcomes [34], [35]. By revealing gaps in student achievement and service provision, data can be used to identify those groups that are being underserved and are underperforming [36]. Once identified, such inequities can be addressed. Such learning data can be used to hold the system accountable for the use of resources by showing whether increased public investment in education has resulted in measurable gains in student achievement. Although direct accountability for results rests mainly with the school, the enabling policy and practice environment is the responsibility of decision-makers at all administrative levels [37].

There is a worldwide concern that learning outcomes have not kept pace with the expansion of education [38]. The extent of the learning deficit is unknown because many countries have few systematic data on who is learning and who is not [34].

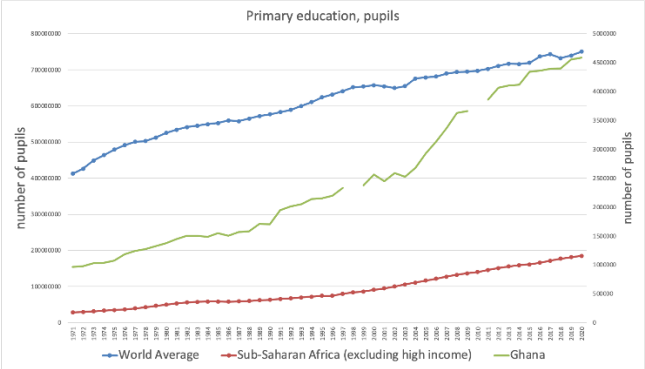
For instance, comparable data on learning outcomes over the past 10 years in sub-Saharan Africa simply does not exist. There is a small exception: in 2020, the regional test serving Africa's francophone countries, PASEC (Programme d'Analyse des Systèmes Educatifs de la CONFEMEN) produced a second round of data on learning outcomes at the second and sixth grade levels for 10 countries that is fully comparable to 2014 results. But how will the progress in these countries compare to that of the region's other 40 countries, or to the largest countries: Nigeria, Ethiopia, South Africa? And what is happening at the secondary level? Impossible to say. Only Senegal and Zambia have participated in any cross-national learning measurement at that level, joining PISA for Development for one round.

Likewise, only Botswana, Ghana, Morocco, South Africa and Tunisia have participated in the Trends in International Mathematics and Science Study (TIMSS) assessments which have been run every four years since 1995.

A good example of the benefits of learning assessment monitoring data in education policy development is Ghana. Ghana currently carries out a National Edu-cation Assessment (NEA) in grades 4 and 6 [35]. In 2013 and 2015, it conducted a national Early Grade Reading Assessment (EGRA) and an Early Grade Mathematics Assessment (EGMA) in Grade 2. Its Grade 8 students participated in the TIMSS in 2003, 2007, and 2001. Ghana's first experience with large-scale assessments dates to the beginning of the 1990s, when the US Agency for International Development (USAID) supported criterion- referenced tests and the World Bank financed performance monitoring tests. In 2004, the NEA (sample based) was created to provide a single national large-scale assessment. Nevertheless, a new National Standardized Assessment Test (NSAT) (census based) is planned for the evaluation of all students. Funded by the Ghana Accountability for Learning Outcomes Project (GALOP), it will start by assessing Grade 4 students, while public funds will be used to extend the assessment to grades 2, 6, and 8 in the future[39].

Ghana's education system ranges from basic to higher education and there is a record of both inbound and outbound student mobility across the education level, although the latter outweighs the former based on affordability. According to [40], there has been significant problems in the past in Ghana's educational system. However, some of these problems remain in education, particularly in rural areas, in the form of acute shortages of trained teachers, educational facilities and learning materials. The recent free secondary education was an attempt to curb the high dropout rate in Ghanaian schools. It is reported that 100,000 children miss out on primary to secondary education each year because their parents cannot afford it. Moreover, literacy standards and learning outcomes remain low despite recent increases in school enrollment. For example, about 70% of high school students did not pass the West African Examinations Council upper secondary education exam in 2014. In addition, there are serious gender disparities between rural and urban areas, as well as disparities in access to education [40]. Despite surges in recent decades, net enrollment in tertiary education also remains low, at just 17% in 2016. This is higher than the Sub-Saharan Africa average of 9%, but less than half the numbers in the Philippines and Indonesia. The fact that the unemployment rate among college graduates is so high does not help prospects for higher education. There was a formal Ghana Association of Unemployed Graduates. Despite these problems, Ghana's overall education system is in good shape compared to many other sub-Saharan African countries, but it lacks inclusion. Countries face daunting challenges when it comes to providing affordable and quality education. Especially given its rapid population growth, to its youth [40].

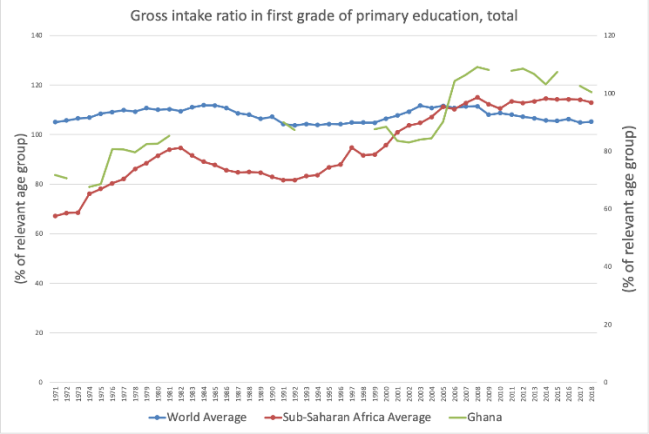
Figure 1: Trend of the Number of Pupils in Primary Education in Ghana



To demonstrate some of the lack of diversity and inclusivity in Ghana's education sector, figures 1, 2 and 3 show primary education, gross intake ration in first grade of primary education, and secondary education, respectively. Primary education pupils are measured in this study as the total number of pupils enrolled at primary level in both public and private schools [15]. Historically, the trend in terms of the number of pupils for Ghana was consistently rising and in line with the world and sub-Saharan average. However, there have been period

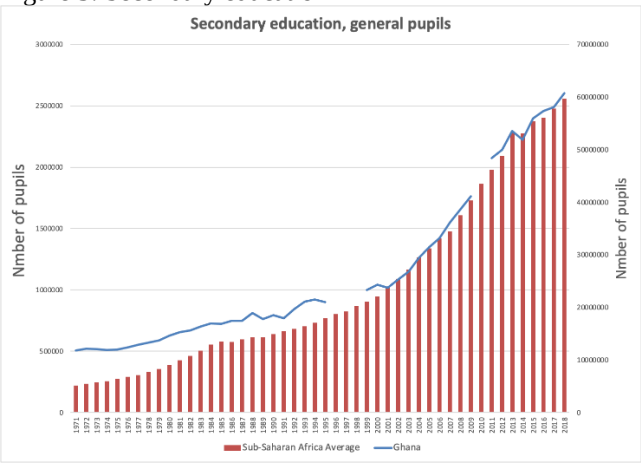
of significant drop in primary education in Ghana reflecting inconsistency in sustaining and keeping pupils in school for primary education in Ghana.

Figure 2: Gross intake ratio in first grade of primary education



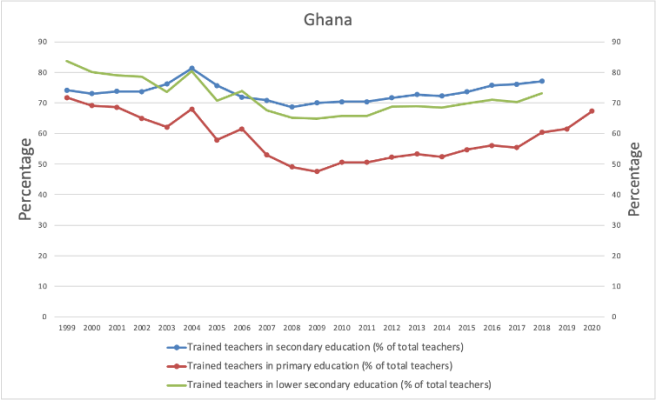
In terms of the gross intake ratio in first grade of primary education, the number of new entrants in the first grade of primary education regardless of age is calculated and expressed as a percentage of the population of the official primary entrance age [15]. As shown in figure 2, Ghana consistently outweighs both sub-Saharan and World average, although the trough in 2013 can be attributed to significant changes in Ghana's approach to enforcing compulsory educational structure at basic/primary level. The recent continual downward trend pre-COVID-19 pandemic levels also demonstrate potential inequality in access to education in Ghana. Hence, the need to revisit the role of technology in enhancing equality and diversity of basic/primary education in Ghana. This is also the case for the data of secondary general pupils in Ghana. This variable is measured as the number of secondary students enrolled in general education programs, including teacher training [15] and is shown in figure 3.

Figure 3: Secondary education



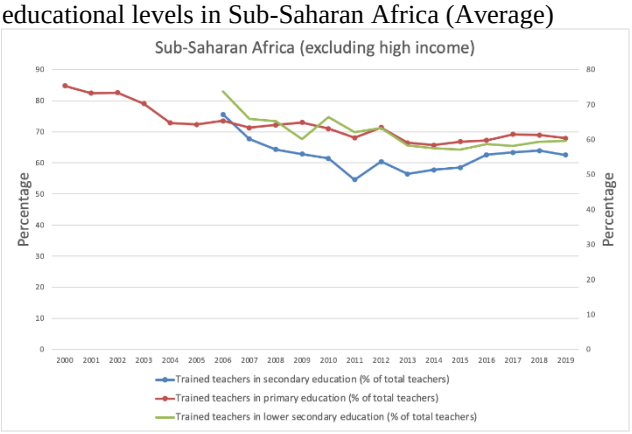
To account for current efforts, and how technology can play a key role in enhancing access, diversity and inclusivity in educational outcomes and provision in Ghana, figures 4 and 5 captures the trend in terms of percentages of trained teachers across the main education levels in Ghana. Trained teachers in secondary education are the percentage of secondary school teachers who have received the minimum organized teacher training (pre-service or in-service) required for teaching in each country [15]. When compared with the trend in sub-Saharan Africa (excluding high income countries), this rate is higher in Ghana overtime. This suggests that an infusion of technology interventions in Ghana, has potentials to improve both delivery and access, as well as have a larger reach throughout the country.

Figure 4: Trend of percentage of trained teachers across educational levels in Ghana



Furthermore, trained teachers in primary education are the percentage of primary school teachers who have received the minimum organized teacher training (pre-service or in-service) required for teaching in each country. This is also measured in line with trained teachers in lower secondary education which is the percentage of lower secondary school teachers who have received the minimum organized teacher training (pre-service or in-service) required for teaching in each country [15]. It is important to note that the percentage of trained teachers in primary education in Ghana is lowest amongst this group. This shows the paucity of interest in equipping trainers (or teachers) at this vital level of important and basic education. There is a need for funding for this level of teacher training to enhance pupils' interest, engagement, and potentially enhance the level of student retention across board in Ghana.

Figure 5: Trend of percentage of trained teachers across educational levels in Sub-Saharan Africa (Average)



V. CONCLUSION

This study sought to explore the challenges in the use of technologies for educational diversity and inclusion of children in undeserved regions with the aim of highlighting the barriers/challenges to technology acceptance and adoption for education by children in underserved regions, presenting an understanding of educational technology and its impact on the educational development of children in underserved regions, and proposing solutions for educational technology adoption and the effectiveness of appropriate accessible technologies for children in underserved regions.

Regarding barriers/challenges to technology acceptance and adoption for education by children in underserved regions, our key findings include acute shortages of trained teachers, educational facilities and learning materials in rural areas. This often results in high dropout rate especially in underserved regions with literacy standards and learning outcomes remaining low despite recent increases in school enrollment.

Concerning presenting an understanding of educational technology and its impact on the educational development of children in underserved regions, our scan of the literature revealed four main thematic areas including access to technology, technology-enabled behavioural intervention, improvements in instructions, and self-led learning which are all highlighted in the background section. These revealed that when educational technologies are made available to children in underserved regions, it can help minimise the education inequality gap which manifests in terms of inclusivity, diversity, equality and equity. It is important to investigate how to maximize the use of technology in African context in order to draw best practices to improve education for the under served children.

Regarding proposing solutions for educational technology adoption and the effectiveness of appropriate accessible technologies for children in underserved regions, we suggest that effective implementation of educational technologies must be easily accessible (hardware and software), promote self-learning (diversity, equity and equality) and must be inclusive (not only to the learners but to their tutors and parents where possible).

Based on the findings, we recommend the following:

1. Governments must provide incentives that will attract more second cycle students to apply to teacher training colleges and become trained teachers who will help in the primary schools since our findings have revealed lack of teachers in this level especially in rural areas. Although the Government of Ghana (GoG) has a policy of paying stipends to teacher trainings at the basic level. However, some of them after completion and posting to the rural areas do not stay and leave the service due to a lot of challenges they face in the rural areas. Thus, the trained teachers posted to such areas must be given specific allowances and other incentives that will let them stay at post.
2. Necessary infrastructure including befitting classrooms, offices, furniture, teachers' bungalows, electricity, portable water, internet connectivity, among others must be made available in rural areas which will help attract and retain trained teachers in the rural areas.
3. Learning materials including computers for teachers and computer labs for the pupils/students must also be made readily available for the schools in the rural areas which will help reduce the digital divide.

This study like all others have some limitations. The main one is the data used which is purely secondary data. Thus, some of the issues might have been addressed since the publishing of these articles. The researchers therefore will be embarking on a survey to collect primary data from Ghana in the near future to ascertain what is actually on the ground regarding use of technologies for educational diversity and inclusion of children in undeserved region. Such data will add to the scarcity of data in this region which was also found to be among the challenges in the use of technologies for educational diversity and inclusion of children in undeserved regions.

REFERENCES

[1] K. Werner and L. Woessmann, "The Legacy of COVID-19 in Education," SSRN Electronic Journal, 2022. [Online]. Available: www.RePEc.org. [Accessed: 10-Aug-2022].

[2] UNICEF Ghana, "Primary and secondary impacts of the COVID-19 pandemic on children in Ghana," Accra, 2021.

[3] A. Bouaamri, F. Otike, and Á. Barátné Hajdu, "Explosion of digital resources and its effects on the development of digital reading culture in Africa," Libr. Hi Tech News, 2022.

[4] G. Omondi, "The state of mobile in Ghana's tech ecosystem | Mobile for Development," Ecosystem Accelerator, 2020. [Online]. Available: https://www.gsma.com/mobilefordevelopment/blog/the-state-of-mobile-in-ghanas-tech-ecosystem/. [Accessed: 04-May-2021].

[5] T. Hatt, H. James, and A. B. Lucini, "Country Overview : Ghana Driving Mobile-Enabled Digital Transformation," Country Overview, 2017. [Online]. Available: www.gsmaintelligence.com. [Accessed: 29-Apr-2021].

[6] K. Bahia et al., "The Welfare Effects of Mobile Broadband Internet: Evidence from Nigeria," Washington DC, 2020.

[7] M. Henderson, N. Selwyn, and R. Aston, "What works and why? Student perceptions of 'useful' digital technology in university teaching and learning," Stud. High. Educ., vol. 42, no. 8, pp. 1567–1579, Aug. 2017.

[8] C. Wekerle, M. Daumiller, and I. Kollar, "Using digital technology to promote higher education learning: The importance of different learning activities and their relations to learning outcomes," J. Res. Technol. Educ., vol. 54, no. 1, pp. 1–17, 2022.

[9] J. Lopez, Y. Nagashima, and E. Y. B. Ackwerh, "Reintegrating Out-of-School Children into Ghana's Formal Education System," Education for Global Development, 2020. [Online]. Available: https://blogs.worldbank.org/education/reintegrating-out-school-children-ghanas-formal-education-system. [Accessed: 28-Apr-2021].

[10] J. Walker, C. Pearce, K. Boe, and M. Lawson, The power of education to fight inequality, vol. 27. Oxford: Oxfarm GB, 2019.

[11] M. Gaddah, A. Munro, and P. Quartey, “The rich or the poor: Who gains from public education spending in Ghana?,” Int. J. Soc. Econ., vol. 42, no. 2, pp. 112–131, 2015.

[12] J. Saavedra Chanduvi, M. C. Aedo Inostroza, O. S. Arias Diaz, A. Pushparatnam, M. Gutierrez Bernal, and F. H. Rogers, “Realizing the Future of Learning: From Learning Poverty to Learning for Everyone, Everywhere,” Washington DC, 2020.

[13] UNESCO UNICEF the World Bank and OECD, “WHAT’S NEXT? Lessons on Education Recovery: Findings from a Survey of Ministries of Education amid the COVID-19 Pandemic,” Paris, New York, Washington D.C., 2021.

[14] M. Trucano, “Promising uses of technology in education in poor, rural and isolated communities around the world,” EduTech, 2014.

[15] World Bank, “Digital Technologies in Education,” Understanding Poverty, 2020. [Online]. Available: https://www.worldbank.org/en/topic/edutech#1. [Accessed: 25-May-2022].

[16] D. Rodriguez-Segura, “EdTech in Developing Countries: A Review of the Evidence,” World Bank Res. Obs., vol. lkab011, 2021.

[17] F. Barrera-Osorio and L. L. Linden, “The use and misuse of computers in education: Evidence from a randomized experiment in Colombia,” 2009.

[18] A. Gaduh, M. Pradhan, J. Priebe, and D. Susanti, “Scores, Camera, Action Social Accountability and Teacher Incentives in Remote Areas,” 2021.

[19] N. Angrist, P. Bergman, and M. Matsheng, “School&Apos;S Out: Experimental Evidence on Limiting Learning Loss Using ‘Low-Tech’ in a Pandemic,” Cambridge, MA, Dec. 2021.

[20] J. Johnston and C. Ksoll, “Effectiveness of Interactive Satellite-Transmitted Instruction: Experimental Evidence from Ghanaian Primary Schools,” No. 17-08, 2017.

[21] B. Böhmer, J. Burns, and L. Crowley, “Testing Numeric : Evidence from a randomized controlled trial of a computer based mathematics intervention in Cape Town High Schools,” in African Economic Conference, 2014, no. September, pp. 0–38.

[22] J. Kotze, B. Fleisch, and S. Taylor, “Alternative forms of early grade structional coaching: Emerging evidence from field experiments in South Africa,” Int. J. Educ. Dev., vol. 66, pp. 203–213, Apr. 2019.

[23] K. Muralidharan, A. Singh, and A. J. Ganimian, “Disrupting education? Experimental evidence on technology-aided instruction in India,” Am. Econ. Rev., vol. 109, no. 4, pp. 1426–1460, Apr. 2019.

[24] K. Büchel, M. Jakob, C. Kühnhanss, D. Steffen, and A. Brunetti, “The Relative Effectiveness of Teachers and Learning Software: Evidence from a Field Experiment in El Salvador,” J. Labor Econ., vol. 40, no. 3, pp. 737–777, 2022.

[25] W. K. Bong and W. Chen, “Increasing faculty’s competence in digital accessibility for inclusive education: a systematic literature review,” International Journal of Inclusive Education. Routledge, 2021.

[26] R. Araya, E. Arias Ortiz, N. Bottan, and J. Cristia, “Does Gamification in Education Work?: Experimental Evidence from Chile,” Inter-American Dev. Bank Dep. Res. Chief Econ., no. July, p. 45, Jul. 2019.

[27] J. Angrist and V. Lavy, “New evidence on classroom computers and pupil learning,” Econ. J., vol. 112, no. 482, pp. 735–765, 2002.

[28] S. Berlinski and M. Busso, “Challenges in educational reform: An experiment on active learning in mathematics,” Econ. Lett., vol. 156, pp. 172–175, Jul. 2017.

[29] United Nations, “Secretary-General’s Nelson Mandela Lecture: ‘Tackling the Inequality Pandemic: A New Social Contract for a New Era,’” United Nations Secretary-General Statements, 2021. [Online]. Available: https://www.un.org/sg/en/content/sg/statement/2020-07-18/secretary-generals-nelson-mandela-lecture-“tackling-the-inequality-pandemic-new-social-contract-for-new-era”-delivered. [Accessed: 26-May-2021].

[30] P. Baxter and S. Jack, “Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers,” Qual. Rep., vol. 13, no. 4, pp. 544–559, 2015.

[31] R. M. Crespo et al., “Aligning assessment with learning outcomes in outcome-based education,” in 2010 IEEE Education Engineering Conference, EDUCON 2010, 2010, pp. 1239–1246.

[32] M. Oakleaf, “Are they learning? Are we? Learning outcomes and the academic library,” Libr. Q., vol. 81, no. 1, pp. 61–82, 2011.

[33] E. F. Barkley and C. H. Major, Learning Assessment Techniques: A Handbook for College Faculty. John Wiley & Sons, Ltd, 2016.

[34] N. Birdsall, B. Bruns, and J. Madan, “Learning Data for Better Policy: A Global Agenda,” 2016.

[35] I. Raudonyte, “The use of learning assessment data: what are we missing?,” Unesco IIEP Learning, 2019. [Online]. Available: https://learningportal.iiep.unesco.org/en/blog/the-use-of-learning-assessment-data-what-are-we-missing. [Accessed: 10-Aug-2022].

[36] J. D. Willms, “Learning divides: Using data to inform educational policy,” 2018.

[37] M. Saito, “The use of learning assessments in policy and planning,” Unesco IIEP Learning, 2015. [Online]. Available: https://learningportal.iiep.unesco.org/en/blog/the-use-of-learning-assessments-in-policy-and-planning. [Accessed: 10-Aug-2022].

[38] C. Valente, “Primary education expansion and quality of schooling,” Econ. Educ. Rev., vol. 73, p. 101913, Dec. 2019.

[39] A. Taddese, “EdTech in Ghana: A Rapid Scan,” Jun. 2020.

[40] M. Kamran, “Education in Ghana,” Education System Profile, 2019. [Online]. Available: https://wenr.wes.org/2019/04/education-in-ghana. [Accessed: 10-Aug-2022].