Published by

British Journal of Contemporary Research

BEXFORD PUBLISHING

Low-Cost Digital Tools And Global Best Practices For Inclusive Basic Education In Rural Schools

Review Article | Volume 1 | Issue 6 | 2026 | Article Number: 079

Accepted: 03 November 2026 | Published: 10 November 2026 | ISSN: 2979-8582 (Online)

Crossref : **https://doi.org/10.67693/BJCR-VQ8LVI7N**

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Abstract

Despite global commitments to Education for All, learners in rural Basic Education schools in Nigeria continue to experience digital exclusion. High-cost technology interventions have largely failed in low-resource contexts due to issues of power, connectivity, cost, and teacher capacity. This conceptual paper explores how low-cost digital tools and global best practices can be adapted to promote inclusive Basic Education in rural schools. Drawing on literature from UNESCO, UNICEF, and successful models in Kenya, India, Bangladesh, and South Africa, the paper synthesizes evidence on frugal edtech solutions such as mobile-based learning, offline content hubs, radio instruction, and low-tech inclusive pedagogies. Anchored on Frugal Innovation Theory and Diffusion of Innovation, the paper proposes a "3A (Access, Adaptability, and Agency) Framework for Rural Inclusion" as guiding principles for adoption. The discussion further presents a "Hub-and-Spoke Model" that leverages solar-powered offline hubs in cluster schools and teacher mobile mentoring as a feasible pathway for Nigerian rural communities. The paper concludes that inclusion in rural Basic Education is achievable without expensive infrastructure. It recommends that UBEC/SUBEB prioritize funding for low-cost, offline-capable tools, invest in teacher digital skills, and pilot context-specific adaptations of proven global models to bridge the rural-urban learning gap.

Keywords: Low-cost Digital Tools, Inclusive Education, Rural Schools, Basic Education, Global Best Practices, Frugal Innovation

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Introduction

Education system is defined and shaped by digital technologies in today's world. Mobile devices, virtual laboratories, digital learning platforms, digital assessment, digital classroom technology, online resources, artificial intelligence, educational applications, radio, and other information and communication technologies, all these have expanded the possibilities for accessing, creating, and sharing knowledge in education system for life-long learning. However, the invention of educational technology has not automatically produced educational inclusion. Since access to technology depends on reliable electricity, broadband connectivity, expensive devices, technical expertise, and continuous financial investment (Terhemba & Ayua, 2026); technology can still reproduce existing socioeconomic and geographical inequalities. UNESCO (2023) posits that educational technology can only be introduced when it is appropriate, equitable, evidence-based, scalable, and sustainable. This concern is important for Basic Education in rural areas. Usually, rural schools in Nigeria operate within environments characterized by inadequate infrastructure, unreliable electricity, poor internet connectivity, teacher shortages, poverty, and limited access to instructional resources. The digital divide operates with the traditional educational divide where learners who already experience disadvantages may also be the least able to benefit from the emerging digital learning opportunities. Okoye et al. (2021) confirms that there are poor internet connectivity, electricity deficits, socioeconomic inequalities, poverty, and weaknesses in ICT policy has contributed substantially to digital exclusion in rural and remote Nigerian communities during the COVID-19 pandemic.

The problem is not as if rural schools lack computers. Somewhat, digital exclusion contains inadequate access to quality devices, connectivity, digital content, technical support, teacher competence, electricity, appropriate languages, and opportunities to use technology meaningfully for learning. Nigeria illustrates both the scale of the challenge and the possibilities for addressing it (UNICEF, 2024). The Nigeria Learning Passport (NLP), launched by the Government of Nigeria and UNICEF in 2022, was designed as an online, mobile, and offline platform to extend learning opportunities to children in schools, homes, and hard-to-reach locations. The broader Nigerian education crisis reinforces the importance of inclusive and flexible approaches. UNICEF (2024) reports that Nigeria has approximately 10.2 million primary-school-age children and 8.1 million junior-secondary-age children out of school, while 74% of children aged 7–14 lack basic reading and mathematics skills. These challenges explicate that educational technology cannot be conceived just as an additional classroom facility. Properly designed, technology can become part of a wider strategy for reaching excluded learners, supporting teachers, providing differentiated instruction, and maintaining learning continuity during emergencies.

However, the solution to this problem is unlikely to be a simple replication of expensive technology models developed for well-resourced environments. The experience of one-laptop-per-child initiatives provides an important warning. According to Cristia et al. (2017) large-scale laptop distribution substantially increased computer access and use but did not produce significant improvements in mathematics or language test scores. More recent evidence indicates that access to hardware alone does not guarantee learning gains. UNESCO (2023) cautions that technology must complement rather than substitute for effective teachers and appropriate pedagogy. This creates a strong argument for frugal approaches to educational technology and emphasizes solutions that respond to real needs while minimizing unnecessary cost, complexity, and resource consumption. In resource-constrained contexts, frugality does not mean inferior quality. Instead, it involves redesigning systems around essential functions and local realities. Hossain (2021) explains that frugal innovations emerge in developing-country environments where innovators must meet important needs with limited financial and material resources. Frugal innovation are solutions that emerge from necessity in resource-constrained environments and

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emphasizes the value of learning from communities when developing such solutions (UNICEF, 2020).

The relevance of frugal approaches to education is further supported by Nigerian scholarship. Ayua (2019a), Ayua et al. (2022), Ayua and Agbidye (2020), Ayua et al. (2026), and Terhemba and Ayua (2026) argue that digital transformation can contribute to educational development when teachers and learners are equipped to use technology creatively and meaningfully. Their emphasis on developing learners' creative minds and technological competencies is particularly relevant to rural education, where digital solutions must be connected to practical educational needs rather than technological novelty. Terhemba and Ayua (2025b), Ayua et al. (2023), Ayua and Ode (2020), Ayua and Tartenger (2020) also shows the value of innovative and inclusive pedagogical approaches for upper-Basic learners, while Ayua (2019a), Ayua, (2019b), Pila and Terhemba (2025) draw attention to the importance of teachers' digital literacy in the implementation of school-based teaching, learning, and assessment. These contributions show that the human and pedagogical dimensions of educational technology deserve as much attention as devices and infrastructure. The central argument of this conceptual paper is that rural digital inclusion requires a shift from technology-intensive models to context-sensitive, low-cost, teacher-supported, and locally adaptable models. Such shift does not imply rejecting advanced technology (Ayua, 2019a). Rather, it means selecting the simplest technology capable of solving the identified educational problem.

Rationale for the Paper

Existing discussions of educational technology emphasize connectivity, computers, tablets, artificial intelligence, learning management systems, and broadband infrastructure. While these technologies have considerable potential, their effectiveness depends on the conditions within which they are introduced. UNESCO (2023) notes that the evidence concerning educational technology remains mixed and that disadvantaged learners are frequently least able to benefit from digital developments. The challenge is significant in Nigeria because rural schools often operate under multiple constraints simultaneously. A digital intervention that assumes constant electricity may be unsuitable in a community where electricity is unreliable. A platform requiring continuous broadband may be ineffective where network coverage is intermittent. A device-heavy model may be unsustainable where schools cannot afford repairs, replace batteries, software updates, or technical support. The critical question is not simply “which technology should rural schools acquire?” but rather: “What combination of affordable technology, pedagogy, teacher support, community participation, and infrastructure can produce sustainable learning opportunities for excluded rural learners?” This conceptual orientation is consistent with the Nigerian National Digital Learning Policy, which identifies bridging the digital divide, reaching underserved communities, producing quality digital content, developing sustainable digital-learning systems, and strengthening teacher capacity as major priorities (Terhemba & Ayua, 2026; Federal Ministry of Education [FME], 2023). The conceptual gap addressed by this paper is the limited synthesis of low-cost technology, inclusive pedagogy, global evidence, and Nigerian institutional structures into a coherent framework for rural Basic Education. Rather than evaluating one intervention empirically, the paper integrates lessons from existing initiatives and proposes a framework that can guide policy, practice, and future empirical research.

This paper has conceptually aimed to examine how low-cost digital tools and global best practices can be adapted to promote inclusive Basic Education in rural schools, with particular attention to the Nigerian context as shown in Figure 1.

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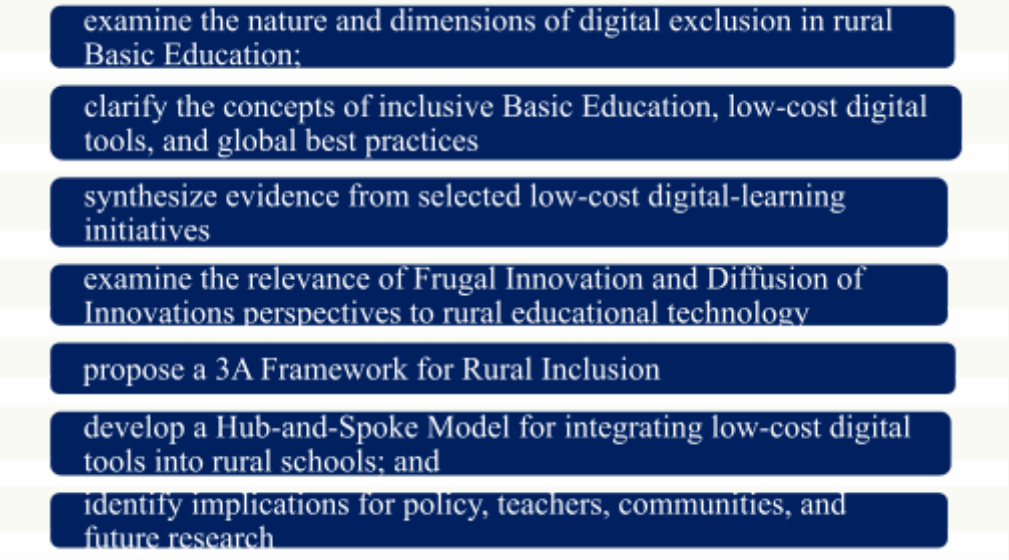


Figure 1: Aims of the Conceptual Paper

Conceptual Clarifications

For the purpose of this paper, the following concepts were clarified.

Inclusive Basic Education in Rural Areas

Inclusive education is much wider than placing children with varied abilities in the same classroom. It encompasses identifying and removing boundaries that can prevent learners from participating in, accessing, and benefiting from quality education. In rural areas exclusion can arise from poverty, disability, gender, geographic isolation, language, insecurity, displacement, inadequate infrastructure, cultural practices, and lack of learning materials. The digital dimension of inclusion has become vital for a discuss. UNICEF (2025) and ITU (2024) note that digital exclusion disproportionately affects poor communities, girls, and children with disabilities because lack of connectivity limits access to learning resources, remote learning opportunities, and digital skills. Inclusive Basic Education in Nigeria may therefore include both school participation and meaningful access to learning opportunities. This embraces children in primary schools, junior secondary schools, non-formal learning centres, and learners who are temporarily or permanently excluded from conventional schooling. The Nigeria Learning Passport provides an important example of this approach. The platform is designed for pre-primary, primary, secondary, and skills education and incorporates online, mobile, and offline functionality to reach learners in environments with weak or absent connectivity.

Low-Cost Digital Tools

There is no universally accepted international price threshold defining a “low-cost digital tool.” For purposes of this conceptual paper, low-cost digital tools are operationally defined as technologies that can provide core educational functions at substantially lower acquisition, deployment, energy, connectivity, and maintenance costs than conventional technology-intensive models. The paper uses less than approximately US$50 per learner-equivalent deployment cost as a heuristic rather than a rigid international standard. More important than the exact price is whether a tool is: affordable to a school and household; capable of functioning with limited or intermittent connectivity; low in energy consumption; simple enough for teachers and learners to use; repairable or replaceable locally; compatible with existing devices; capable of supporting inclusive and differentiated learning; and sustainable beyond a short-term donor-funded project. Such examples are shown in Figure 2.

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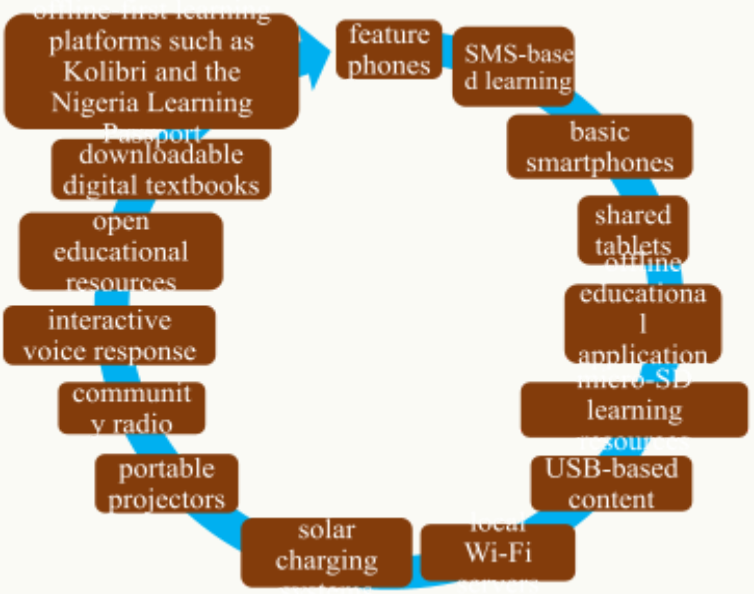


Figure 2: Low-Cost Digital Tools

This approach is consistent with UNESCO's (2023) position that technology does not have to be advanced to support learning in hard-to-reach communities. Radio instruction, for example, remains an important educational technology in many countries.

Global Best Practices

Global best practices refer in this paper as the documented approaches, models, or practices that have showed practical value in comparable educational environments and from which context-sensitive lessons can be adapted. Best practice does not mean direct transplantation. A model that works in Kenya, India, Bangladesh, or South Africa cannot automatically be transferred to Nigeria. Differences in language, curriculum, infrastructure, teacher preparation, culture, financing, governance, and community organization must be considered. Thus, the relevant principle is adaptation rather than imitation.

Digital Exclusion and Rural Basic Education

The Figure 3 shows that the rural digital divide has at least five interconnected dimensions.

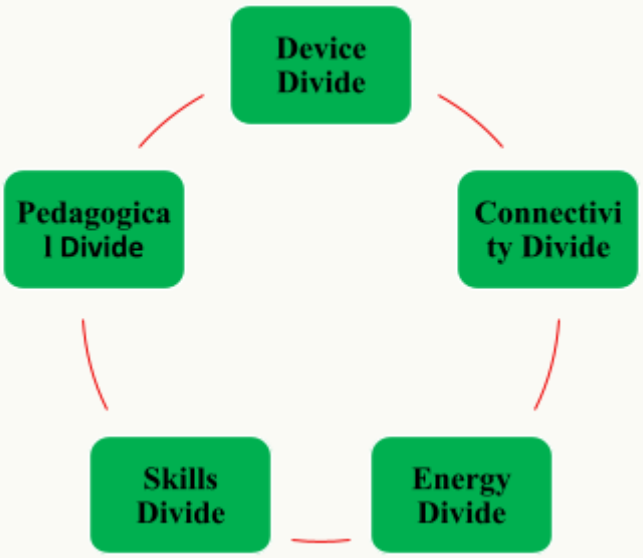


Figure 3: Rural Digital Divide

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Device divide in Figure 3 presents that many learners do not personally own smartphones, tablets, computers, or other digital devices. Even where households possess phones, devices may be shared among several family members, limiting children's independent learning opportunities. Connectivity divide means that the internet connectivity remains highly unequal. Rural and remote communities may have weak network coverage, expensive data, or no reliable internet service. This makes online-only learning platforms inappropriate for many schools. Energy divide shows that the electricity is a foundational requirement for many forms of digital learning. Without reliable electricity power supply, devices cannot be charged and routers, projectors, computers, and servers cannot function consistently. Solar energy therefore deserves consideration as an enabling component of rural digital learning rather than merely an environmental technology. Skills divide explicate that having access to a device does not automatically create digital competence. Teachers need the capacity to select, adapt, integrate, troubleshoot, and evaluate digital resources. Pila and Terhemba (2025), for example, found concerns about the level of digital literacy skills among basic school teachers in Benue State in relation to continuous assessment implementation. This finding reinforces the need to place teacher competence at the centre of rural digital transformation. Pedagogical divide shows that technology can widen inequalities if it simply transfers conventional teaching practices to digital devices. Effective digital inclusion requires teachers to use technology to differentiate instruction, provide feedback, facilitate collaboration, support independent learning, and reach learners with different needs. UNESCO (2023) maintains that this is important because technology should complement rather than replace teacher interaction.

Limitations of One-Laptop-Per-Child Models

One-laptop-per-child programmes represent an influential approach to digital inclusion. Their underlying assumption is that adding the number of devices available to learners will improve access to information and could enhance learning. Research shows that this assumption is incomplete as Cristia et al. (2017) found that an OLPC programme substantially increased the availability and use of computers but did not generate significant effects on mathematics and language achievement. This finding does not mean that computers are ineffective. Instead, it shows that device access is only one component of educational improvement. According to UNESCO (2023) educational technology produces benefits under particular conditions and that the absence of teacher preparation, inappropriate content, excessive technology use, or high implementation costs can undermine expected benefits. For rural Nigeria, therefore, the policy objective cannot be “one learner, one expensive device” at all costs. A more realistic approach may be one community, several shared digital resources, supported by teachers and offline content. A shared solar-powered digital hub, for example, could serve several classes, teachers, and nearby schools at a fraction of the cost of individually distributing high-end devices.

Thematic Review of Global Models and Low-Cost Tools

Here review of global models and low-cost tools are discussed as represented by Figure 4.

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Figure 4: Thematic Review of Global Models and Low-Cost Tools

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Global Initiatives with Relevance to Nigeria

Here is the global initiative with relevance to Nigeria presented in Figure 5.

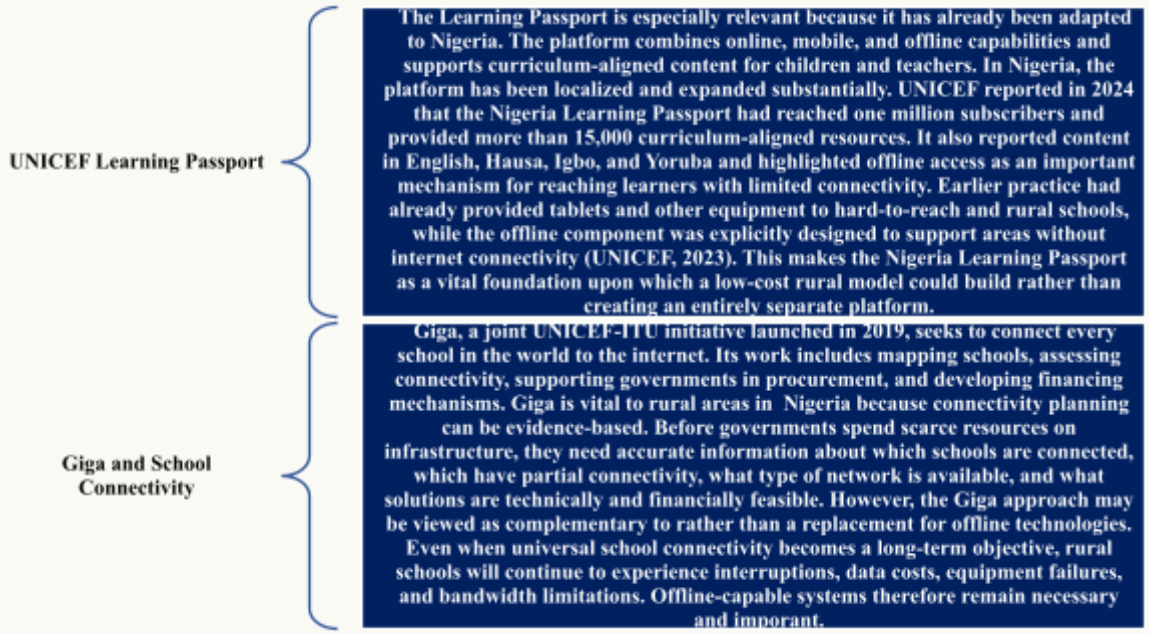


Figure 5: Global \Initiatives with Relevance to Nigeria

Theoretical Framework

This paper is anchored on two theories: Hossain's (2021) Frugal Innovation Perspective which provides the theoretical foundation for this paper and focuses on creating useful solutions under resource constraints while reducing unnecessary cost and complexity. Hossain (2021) explains that frugal innovations are actually relevant to underserved communities in developing countries because they seek to provide value using limited resources. The concept is appropriate for rural Basic Education because rural schools face multiple constraints simultaneously. A successful technology intervention must therefore do more to reduce the purchase price. It must also minimize: energy requirements; data costs; maintenance costs; training burden; technical complexity; dependence on external experts; and replacement costs. Frugal education means doing more educationally with fewer technological resources. However, frugality may not be confused with cheapness. A very cheap device that breaks frequently or requires expensive proprietary software may ultimately be more costly than a slightly more expensive but durable and repairable alternative. Frugal design must therefore consider total cost of ownership.

Frei-Landau's et al. (2022) Diffusion of Innovations Theory, which explains how innovations spread through social systems and emphasizes characteristics such as relative advantage, compatibility, complexity, trialability, and observability Nowadays educational technology research continues to show the usefulness of this perspective. Frei-Landau et al. (2022), for example, applied Diffusion of Innovations Theory to mobile-learning adoption and found that adoption is a process requiring opportunities to use, reflect on, and repeatedly try technological innovations. This perspective is highly relevant to rural schools. Teachers are more likely to adopt technology when they perceive it as: useful for their teaching; compatible with existing practices; easy to use; capable of being tested before full adoption; and visibly beneficial to learners. Menzli et al. (2022) posits that perceived relative advantage, compatibility, complexity, and trialability influence adoption decisions. The theory therefore supports the argument that rural technology initiatives can begin with small pilots, demonstrations, mentoring, and teacher participation rather than immediate large-scale deployment.

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The 3A Framework for Rural Inclusion

Based on the reviewed literature, this paper proposes the 3A Framework for Rural Inclusion, consisting of the following as shown in Figure 6.

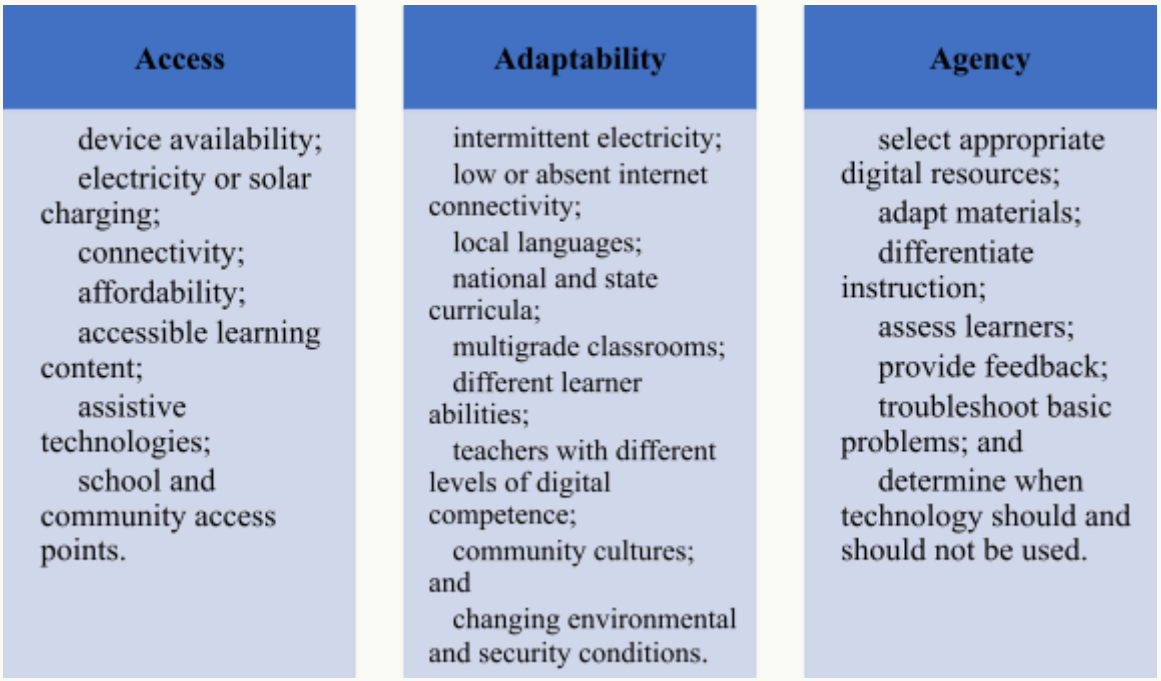


Figure 6: 3A Framework for Rural Inclusion

As shown in figure 6, access concerns whether learners and teachers can physically and economically use the technology. Access is the foundation, but access alone is insufficient. A school may possess tablets without teachers knowing how to use them, or have internet connectivity without curriculum-relevant content. Adaptability as presented in Figure 6 shows whether the technology can function within the actual educational environment. The Nigeria Learning Passport illustrates the importance of adaptability because it combines online, mobile, and offline functions and incorporates locally contextualized content. Agency as presented in Figure 6 concerns whether teachers, learners, parents, and communities can meaningfully use and shape the technology. Learner agency involves opportunities to learn independently, collaborate, ask questions, create content, and monitor progress. Community agency involves participation in decisions concerning technology selection, maintenance, security, and sustainability. These dimensions are interconnected. It means that access without adaptability = technology that cannot function effectively. Adaptability without agency = technology that exists but is poorly used. Agency without access = capable teachers and learners without the necessary resources. Thus: Access + Adaptability + Agency = Inclusive rural digital education

Hub-and-Spoke Model for Rural Nigerian Schools

The paper further also shows a Hub-and-Spoke Model for operationalizing the 3A Framework.

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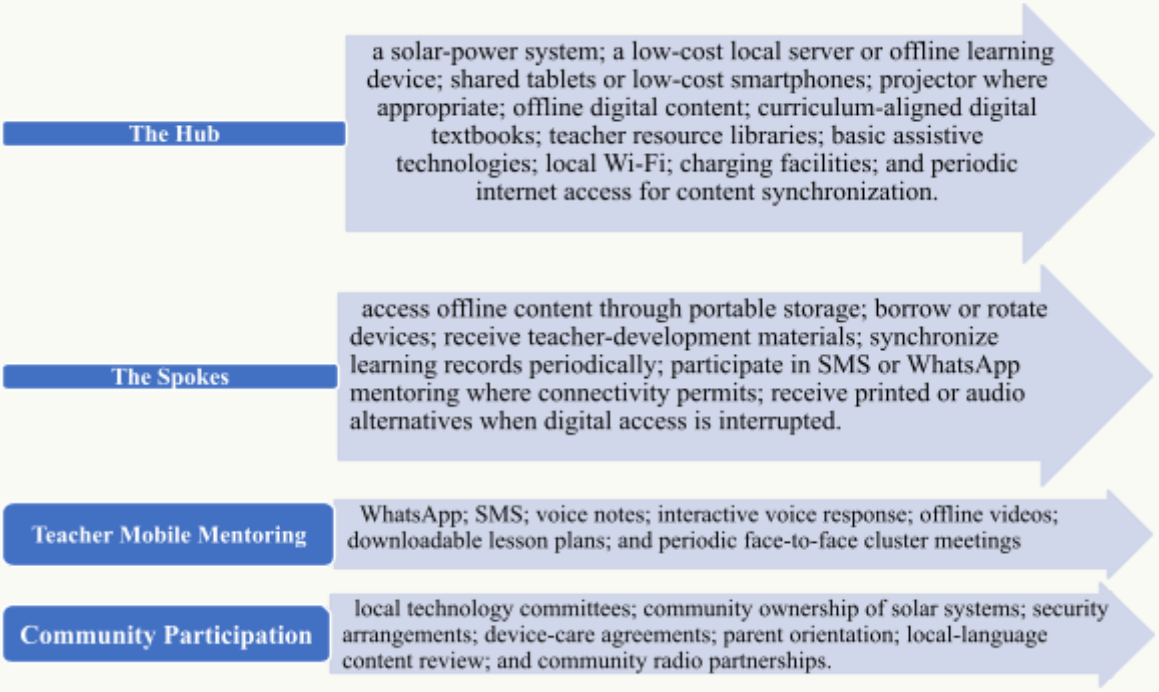


Figure 7: Hub-and-Spoke Model

The Hub can be strategically selected in rural schools equipped with all that is shown in Figure 7. The hub does not need continuous broadband; however, it can periodically connect to the internet to download updates, assessment resources, teacher-training materials, and new content. The Spokes may consist of nearby schools connected pedagogically rather than necessarily through permanent broadband, Teachers in spoke schools could be presented as shown in Figure 7. This creates a cluster-based economy of scale. Instead of purchasing a complete technology infrastructure for every small rural school, several schools can share selected resources while retaining their local teaching structures. Teacher Mobile Mentoring serves as a central component of the model. Teachers could receive short professional-development modules as presented in Figure 7. This approach recognizes that teacher capacity is central to educational technology. Terhemba and Ayua's (2025a) work on creative and innovative learning approaches shows the importance of teacher-mediated instructional strategies at the Basic Education level, while Pila and Terhemba (2025) highlight the need to strengthen teachers' digital literacy in Nigerian basic schools. Community participation as shown in Figure 7 is vital because technological sustainability depends on local ownership. A donated device that nobody is responsible for maintaining is unlikely to remain functional for long.

Adapting Global Best Practices to Nigerian Rural Basic Schools

Here are the best global practices to Nigerian rural basic schools.

Power and Energy

Power availability can be treated as a fundamental educational issue. Solar charging systems provide a promising alternative as they can support tablets, phones, projectors, local servers, and routers without depending entirely on the national electricity grid. However, solar systems can be designed according to actual energy requirements. Procurement can consider battery replacement, technical support, security, and maintenance rather than just the initial installation price.

Network Limitations

The assumption that every rural school may immediately become a fully online school is unrealistic. A

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more resilient strategy is a three-level connectivity architecture as shown in Figure 8:



Figure 8: Three-level connectivity architecture

This layered model as shown in Figure 8 ensures that learning continues even when the highest level of connectivity fails.

Language and Cultural Relevance

Digital inclusion must also be linguistic inclusion. UNICEF's (2024) Nigeria Learning Passport shows the importance of multilingual content, with resources available in English, Hausa, Igbo, and Yoruba. Additional localization may be required in rural schools. Digital content can reflect local examples, environments, social, occupations, cultural practices, and community realities. Local teachers may participate in content adaptation rather than just receiving externally developed materials.

Teacher Digital Literacy

Technology programmes often fail when teacher preparation is treated as a secondary issue. Teacher training may focus on pedagogical digital competence, not just computer operation. Teachers should learn how to do the following as presented in Figure 10.



Figure 10: Digital Literacy Teachers can Learn

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Capacity building for teachers in digital literacy can be emphasized. The work of Terhemba and Ayua (2025a) on innovative approaches in Basic Science and Pila and Terhemba (2025) on teachers' digital literacy provides Nigerian evidence supporting the importance of teachers' capacity and innovative instructional practice.

Opportunities for Rural Nigeria

Many prospects exist for practicing this model. The mobile-phone availability makes available a foundation for low-cost communication and learning. Mobile technologies can support SMS-based revision, teacher mentoring, voice lessons, parental communication, and emergency learning. Also, Nigeria has institutional structures through UBEC, SUBEBs, ministries of education, teacher-training institutions, schools, and community organizations that can support cluster-based interventions. The Nigeria Learning Passport provides an existing national digital platform rather than requiring states to create entirely new systems. UNICEF (2022) reports that the platform has expanded substantially and includes offline functionality designed for learners with limited connectivity. Giga's school-connectivity mapping and planning work makes available a potential basis for evidence-based connectivity investments. Fifth, community radio remains a potentially powerful medium for reaching learners in locations where internet-based solutions remain difficult to sustain.

Challenges and Risks

Here are the challenges of educational technology as presented in Figure 11.

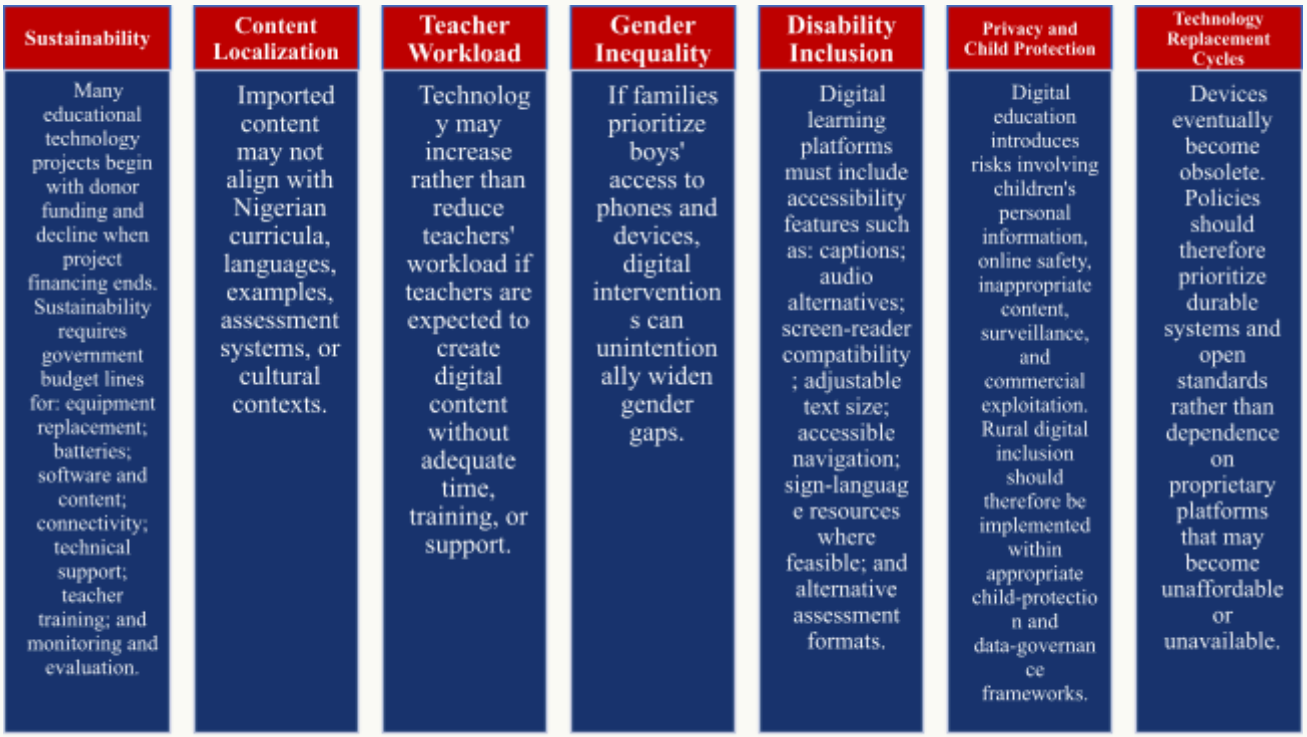


Figure 11: Challenges and Risk of Technology Education

Implications

Here are the implications of the policy.

Policy Implications

UBEC and SUBEB Funding Priorities: UBEC and SUBEBs can consider shifting part of educational technology investment from expensive device-centred projects toward low-cost, shared, offline-capable

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systems. Funding criteria may assess following as shown Figure 12.

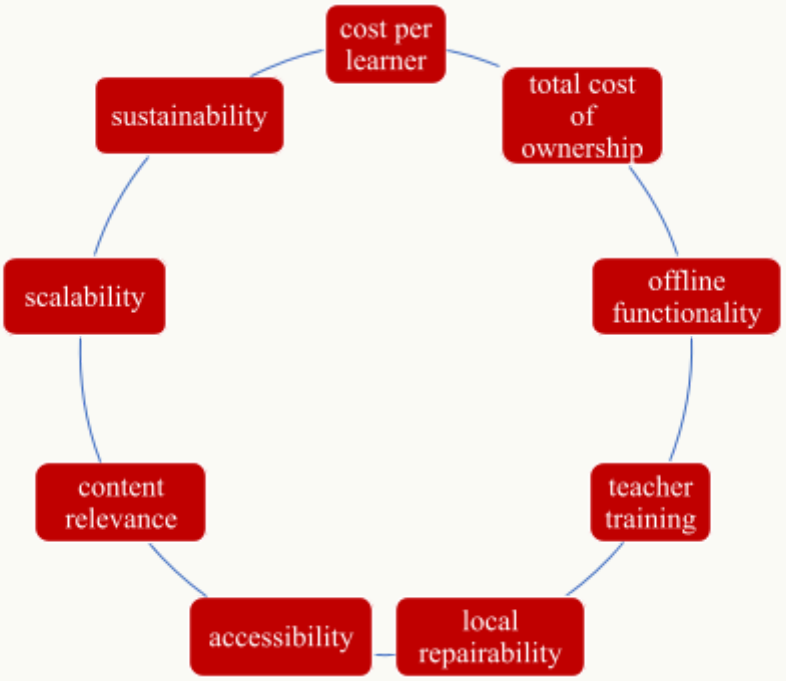


Figure 12: Funding criteria for Educational Technology

- **Rural Digital Education Standards:** Nigeria may establish minimum standards for rural digital-learning deployments. Such standards can address electricity power supply, device durability, accessibility, data protection, teacher preparation, content localization, and technical support.
- **Integration with Existing Platforms:** Rather than developing multiple parallel digital platforms, states can explore integration with existing national resources such as the Nigeria Learning Passport.
- **Community Radio and Mobile Learning:** Education authorities can consider partnerships with community radio stations and telecommunications providers to deliver educational audio, SMS, and voice-based learning.
- **Teacher Professional Development:** Digital training could become continuous rather than project-based. Teachers can receive ongoing support through cluster meetings, mobile mentoring, peer networks, and school-based professional development.

Practice Implications

Teachers cannot be expected to become technology specialists. Instead, they can become pedagogically confident users of appropriate technologies. For instance, a teacher in a rural Basic 5 classroom might: Assess learners' reading levels; divide them into appropriate learning groups; use an offline tablet to provide differentiated reading activities; use an audio recording to support learners with reading difficulties; send short SMS practice tasks to families where phones are available; use printed materials for learners without device access; record progress using simple digital or paper-based assessment; and synchronize data periodically when connectivity becomes available. Such a model considers pedagogy before technology. The approach is in line with the evidence from Teaching at the Right Level, which shows that assessment, targeted instruction, mentoring, and teacher support are more important than just supplying teaching materials (Abdul Latif Jameel Poverty Action Lab [J-PAL], 2019).

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Research Implications

The framework requires empirical testing therefore future researchers can investigate: the effectiveness of solar-powered offline learning hubs in rural Nigerian schools; the cost-effectiveness of shared-device versus one-device-per-learner models; the effect of SMS-based learning on literacy and numeracy; the effectiveness of interactive radio instruction in rural primary schools; teacher adoption of offline platforms; gender differences in access to rural digital tools; accessibility of low-cost digital tools for learners with disabilities; the effect of teacher mobile mentoring on technology integration; the sustainability of community-owned solar digital hubs; and the effect of the 3A Framework on learner participation and achievement. Research could compare technology packages rather than isolated devices. For instance, a future study could compare: Package A**:** tablets only; Package B: tablets + solar power; Package C**:** tablets + solar power + offline content + teacher mentoring; Package D: tablets + solar power + offline content + teacher mentoring + community radio. These designs can provide stronger evidence concerning the combination of conditions required for sustainable rural digital inclusion.

Conceptual Logic Model

This approach can be represented as shown in Figure 12.

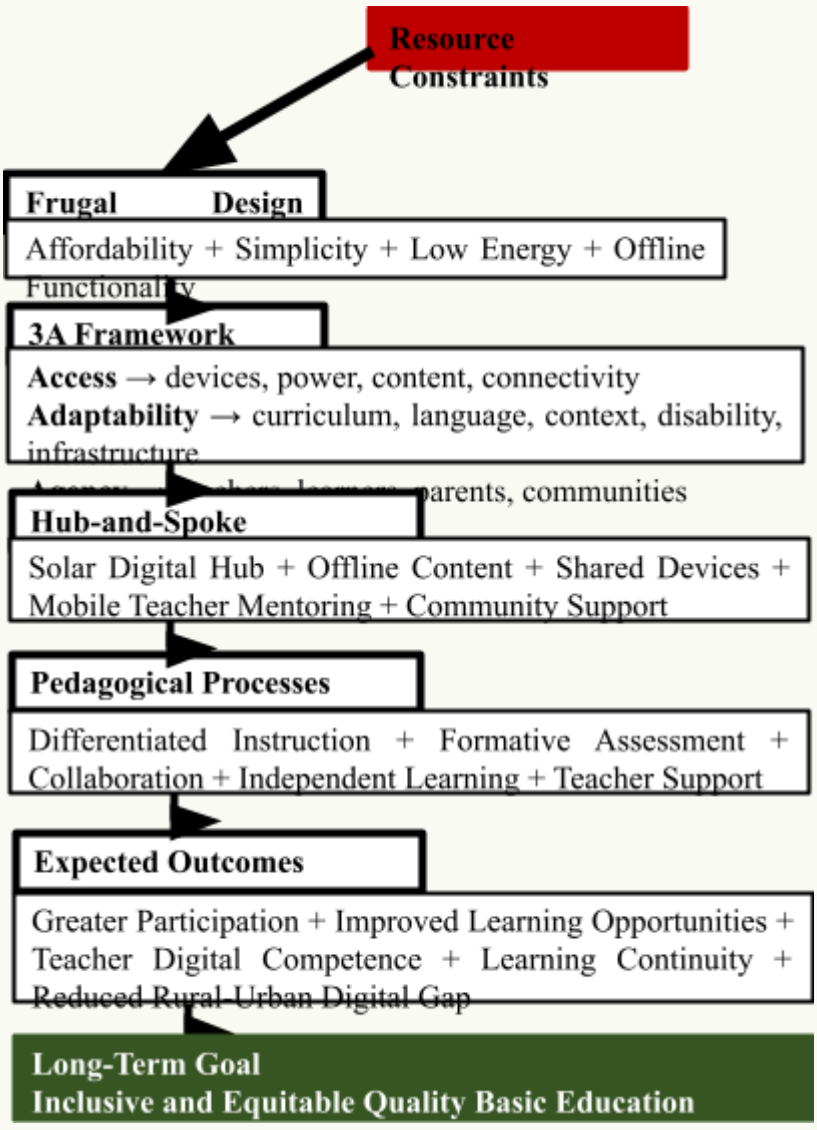


Figure 12: Conceptual Logic Model

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Discussion

The focus of this review suggests that the major problem facing rural digital education is not just technological scarcity but a mismatch between technology models and educational realities. High-cost models may be attractive because they provide visible infrastructure, but their sustainability and educational effectiveness depend on complementary conditions. Cristia et al. (2017) evidence from one-laptop-per-child programmes shows that increased access to computers does not automatically translate into improved learning outcomes. In the same way evaluations of offline digital platforms show that technology can increase access and engagement without necessarily generating immediate improvements in standardized test scores. Dissimilarly, many low-cost approaches show promise when technology is integrated with pedagogy. Eneza Education (2024) reveals how simple mobile phones can support curriculum-linked learning. Interactive radio instruction in Nigeria provides evidence that low-tech communication can improve literacy among highly vulnerable learners. J-PAL (2019) laments that teaching at the Right Level explicate that targeted instruction, teacher support, and learner assessment can produce substantial improvements without requiring sophisticated technological infrastructure. These instances all point to a wider principle: the educational value of technology depends more on how technology is embedded in an instructional system than on the sophistication of the technology itself**.**

This is compatible with UNESCO's (2023) that technology on our term's position, which stresses appropriateness, equity, evidence, scalability, and sustainability. The Nigeria Learning Passport offers a vital opportunity because the country does not have to start from zero. Its online, mobile, and offline capabilities provide a platform that can potentially support the proposed Hub-and-Spoke approach. The challenge is to ensure that deployment reaches the most underserved schools and that technology is accompanied by teacher development, localized content, community participation, and sustainable financing. Ayua and Terhemba's (2025) is relevant to this concern because their recent work stresses creative, innovative, and technology-related approaches to learning at the Nigerian Basic Education level. Also, Ayua et al. (2022), and Terhemba and Ayua (2026) stress the role of digital change and technological competence in educational development, while Terhemba and Ayua (2025b) reveal the potential of creative approaches to strengthening learning among upper-Basic students. Pila and Terhemba's (2025) work on teachers' digital literacy further underscores the human-capacity dimension of digital transformation. The 3A Framework here extends these ideas by arguing that rural inclusion requires the simultaneous presence of access, adaptability, and agency. A programme may have adequate devices but fail because teachers cannot use them. It may have trained teachers but fail because electricity is unreliable. It may have electricity and devices but fail because the content is linguistically or culturally inappropriate. Sustainable inclusion therefore requires the interaction of all three dimensions. The Hub-and-Spoke Model provides a practical mechanism for operationalizing the framework. By concentrating expensive infrastructure such as solar systems, servers, projectors, technical support, and periodic connectivity in cluster hubs, governments may achieve economies scale while still extending learning resources to smaller schools. The model also creates opportunities for teacher communities of practice, peer mentoring, resource sharing, and collaborative problem solving. The proposed approach is not intended to replace the long-term goal of universal internet connectivity. Giga's global connectivity agenda remains essential because meaningful digital participation ultimately requires reliable connectivity. However, universal connectivity is a long-term infrastructure objective, whereas children need learning opportunities now. Offline-first and low-bandwidth approaches provide a bridge between current realities and future connectivity.

Conclusion

This paper has argued that inclusive Basic Education in rural schools does not require the immediate deployment of expensive, high-bandwidth, one-device-per-child technology systems. Evidence from

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Nigeria and other low-resource contexts indicates that meaningful educational improvement depends on the interaction between technology, pedagogy, teacher competence, infrastructure, and community support. Low-cost tools such as mobile phones, SMS, radio, offline digital platforms, shared tablets, solar charging systems, and open educational resources can provide valuable alternatives or complements to high-cost technology. International experiences from Kenya, South Africa, India, Bangladesh, and other settings shows that the most useful innovations are often those that fit the realities of the communities they serve. The paper proposes the 3A Framework for Rural Inclusion: access ensures that learners and teachers can reach the necessary resources; adaptability ensures that technologies function within local infrastructure, language, curriculum, and cultural conditions; and agency ensures that teachers, learners, parents, and communities can meaningfully use and influence the technology. The Hub-and-Spoke Model translates these principles into an operational strategy involving solar-powered offline hubs, shared devices, localized digital content, mobile teacher mentoring, community participation, and periodic connectivity. The model offers a potentially scalable pathway for UBEC, SUBEBs, state ministries of education, development partners, and rural communities. The central argument is straightforward: digital inclusion cannot be measured by how many expensive devices a school possesses, but by how effectively technology expands meaningful learning opportunities for children who could otherwise be excluded**.** For rural Nigeria, Frugal (economical), offline-capable, teacher-supported, locally adaptable technologies may provide a more sustainable pathway toward inclusive Basic Education than technology-intensive approaches designed for high-resource environments.

References

Abdul Latif Jameel Poverty Action Lab (2024). Evaluation for Kenya education. https://www.povertyaction

Ayua, G. A. (2019a, July). *The value of ICT- driven basic education in the 21st century.* A Keynote Speech Delivered on the Occasion of the 1st Speech and Prize-giving Ceremony of Fajude Academy, Makurdi, Benue State, Nigeria. https://www.researchgate.net/publication/337973485

Ayua, G. A. (2019b). Creative teaching of science in the 21st century. In P. O. Agogo and E. E. Otor (Eds.), *Methods and Resources in Science Teaching in Nigeria* (PP 174 - 192). Optimism Academic Publishers. https://www.researchgate.net/publication/337244699

Ayua, G. A. & Ode, J. O. (2020). Science-technology-society strategy's effect on students' interest in Basic Science at upper-basic school level. *Africa Journal of Sustainable Professional Development, 4*(1), 5 - 11. https://www.researchgate.net/publication/354817666

Ayua, G. A. & Agbidye, A. (2020). Effect of science-technology-society strategy on entrepreneurial creativity among upper-basic school students. *Journal of Science, Technology and Education, 4*(9), 105-113. http://nsukjste.com/

Ayua, G. A. & Tartenger, T. T. (2020). Effect of science-technology-society strategy on performance in Basic Science among upper-basic school students in Makurdi metropolis. *Africa Journal of Sustainable Professional Development, 4*(1), 26 - 33. https://www.researchgate.net/publication/354817767

Ayua, G. A., Gowon, E. K., & Omaga, J. O. (2022). Cultivating creative minds and hands in science and technology for sustainable advancement in post COVID19 era: Educational implications. *Lafia Journal of Education, 3*(2), 72–80.

© 2026 The Authors. Published by Bexford Publishing Ltd

Ayua, G. A., Adadu, C. A. & Angura, M. T. (2023). Fostering creative minds and hands in science, technology and engineering for sustainable growth in post COVID-19 era. *Journal of Technology, Industrial Studies and Science, 7*(10), 416-425. https://www.scholarj.com/jtiss/

Ayua, G. A., Taangahar, B. A., Ikyernum, G. S., Iorkase, R. N., & Kwaghtongu, R. T. (2026). Exploring gender as a correlate of undergraduates' interest in science and technology education. *British Journal of Contemporary Research, 1*(1), Article 006. https://bexfordpublishing.co.uk/journals/bjcr/articles/BEX_MAY_26_009

Belloe, S. A., Oluyemi, A. A., & Apukeg, O. D. (2022). Learning through interaction: Impact of interactive radio instructions in improving literacy skills of out-of-school children in IDP camps in Nigeria. *Interactive Learning Environments, 32*(3), 1058–1067. DOI: 10.1080/10494820.2022.2110124.

Cristia, J., Ibarrarán, P., Cueto, S., Santiago, A., & Severín, E. (2017). Technology and child development: Evidence from the One Laptop per Child program. *American Economic Journal: Applied Economics, 9*(3), 295–320. DOI: 10.1257/app.20150385.

Eneza Education (2024). SMS/USSD/WhatsApp Learning + teacher analytics dashboard. https://www,enezaeducation.com

Federal Ministry of Education. (2023). *National Digital Learning Policy*. Abuja, Nigeria: Federal Ministry of Education.

Frei-Landau, R., Muchnik-Rozanov, Y., & Avidov-Ungar, O. (2022). Using Rogers' diffusion of innovation theory to conceptualize the mobile-learning adoption process in teacher education in the COVID-19 era. *Education and Information Technologies, 27*, 12811–12838. DOI: 10.1007/s10639-022-11148-8.

Hossain, M. (2021). Frugal innovation and sustainable business models. *Technology in Society, 64*, 101508. DOI: 10.1016/j.techsoc.2020.101508.

Jamel Menzli, L., Smirani, L. K., & Boulahia, J. A. (2022). Investigation of open educational resources adoption in higher education using Rogers' diffusion of innovation theory. *Heliyon, 8*(7), e09885. DOI: 10.1016/j.heliyon.2022.e09885.

Jordan, K., et al. (2025). Supporting equitable access to learning via SMS in Kenya: Impact on engagement and learning outcomes. *British Journal of Educational Technology*. DOI: 10.1111/bjet.13533.

Learning Equality. (2021). *Stories of education continuity during COVID: Leveraging edtech without Internet using Kolibri*. Learning Equality.

Okoye, K., Anagün, A. O., & others. (2021). Left behind? The effects of digital gaps on e-learning in rural secondary schools and remote communities across Nigeria during the COVID19 pandemic. *International Journal of Educational Research Open, 2*, 100092. DOI: 10.1016/j.ijedro.2021.100092.

Pila, N., & Terhemba, W. K. (2025). Basic school teachers' application of digital literacy skills in the implementation of continuous assessment in Benue State. *BSU Journal of Science, Mathematics and Computer Education, 5*(1), 207–219.

Teaching at the Right Level Africa. (2022). *Supporting learning in and out of school: Experimental evidence from India*. Teaching at the Right Level Africa.

© 2026 The Authors. Published by Bexford Publishing Ltd

Terhemba, W. K., & Ayua, G. A. (2025a). Developing creative skills among varied cognitive style upper-basic 3 students in Basic Science using creative exploration in Gboko. *FNAS Journal of Mathematics and Science Education, 6*(3), 89–99. DOI: 10.63561/fnas-jmse.v6i3.899

Terhemba, W. K., & Ayua, G. A. (2025b). Impact of creative exploration on upper-Basic Science students' creative hands development in Gboko. *International Journal of Scientific Research in Multidisciplinary Studies, 11*(5), 91–100.

Terhemba, W. K., & Ayua, G. A. (2026). Qualitative study on digital classrooms, equal futures: artificial intelligence-powered digital pedagogy for closing the gender digital divide in stem. *Zamfara International Journal of Education*, *6*(5), 321-333. https://doi.org/10.64348/zije.2026552

United Nations E Education Scientific and Cultural Organisation (UNESCO, 2023). *Global education monitoring report 2023: Technology in education—A tool on whose terms?* Paris, France: UNESCO. https://www.unisco.com

United Nations International Children's Emergency Fund (UNICEF, 2022). *12 million Nigerian students to have increased access to education through new Learning Passport*. UNICEF Nigeria. https://www.unicef.org

United Nations International Children's Emergency Fund (UNICEF, 2023). *Digital learning platforms can increase access to quality education for children in Nigeria*. UNICEF Nigeria. https://www.unicef.org

United Nations International Children's Emergency Fund (UNICEF, 2024). *Immediate action needed to protect Nigeria's children and schools*. UNICEF Nigeria. https://www.unicef.org

United Nations International Children's Emergency Fund (UNICEF, 2020). *Frugal innovation: What we have learned*. UNICEF Office of Innovation. https://www.unicef.org

United Nations International Children's Emergency Fund (UNICEF, 2024). *Nigeria Learning Passport reaches one million subscribers: A milestone in educational access*. UNICEF Nigeria. https://www.unicef.org

United Nations International Children's Emergency Fund [NICEF] & International Telecommunication Union (ITU, 2023). *Giga: Connecting every school to the Internet*. https://www.unicef.org and https://www.itu.int

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