Offline Internet-Based Personalized Remote Learning for Economic Development in Africa

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Abstract

The rapid expansion of digital education has transformed learning opportunities worldwide, yet internet connectivity remains a significant barrier in many African regions. Offline internet-based personalized remote learning offers a viable solution by leveraging preloaded digital contents, adaptive learning technologies, and localized educational resources. This study explores the role of offline learning platforms in addressing educational inequities, enhancing skill acquisition, and driving economic development across Africa. By examining theoretical frameworks, technological implementations, and real-world case studies, the study highlights the challenges and opportunities associated with these learning models. The findings suggest that strategic investments in offline learning infrastructure, educator's training, and policy support can bridge the digital divide and promote sustainable economic growth. The study concludes that offline internet models can provide meaningful and equitable educational opportunities even in the absence of continuous internet connectivity enabling personalized learning for economic emancipation with recommendations for leveraging artificial intelligence, mobile-based offline learning, and public-private partnerships to enhance educational outcomes and workforce development.

Keywords: Offline learning, personalized education, digital divide, economic development, Africa

Introduction

Africa's educational landscape is undergoing a significant transformation, driven by the urgent need to bridge the digital divide and enhance access to quality education. Despite the global shift towards digital learning, many regions in Africa continue to face challenges such as limited internet connectivity, high data costs, and inadequate infrastructure. These obstacles hinder the implementation of online learning solutions, particularly in remote and underserved communities (UNESCO, 2022).

To address these challenges, offline internet-based personalized remote learning has emerged as a viable alternative. This approach leverages preloaded digital contents, adaptive learning technologies, and localized educational resources to deliver tailor made learning experiences without the need for continuous internet access. By circumventing the limitations of online connectivity, offline learning platforms can provide equitable educational opportunities to learners across diverse socio-economic backgrounds (Adie, Bisong, & Obuop, 2021).

The digital divide remains a pressing issue in Africa, with significant disparities in access to information and communication technologies (ICTs) between urban and rural areas. According to UNESCO (2022), only 40% of primary schools and 50% of lower-secondary schools in Africa are connected to the internet, highlighting the infrastructural challenges faced by the education sector. The high cost of internet connectivity further exacerbates the situation, making it difficult for governments to sustain digital education initiatives solely through domestic budgets (World Bank, 2021).

In Nigeria, for instance, the digital divide poses a significant barrier to achieving Sustainable Development Goal 4 (SDG 4), which aims to ensure inclusive and equitable quality education for all. A study on Nigeria's digital divide emphasized the potential of offline internet solutions in bridging this gap, offering cost-effective and accessible learning opportunities to students in low-resource environments (Adie, Bisong, & Obuop, 2021).

Personalized learning strategies are central to the effectiveness of offline remote learning. By tailoring educational contents to individual learners' needs, preferences, and learning styles, personalized learning enhances engagement and improves learning outcomes. Adaptive learning technologies, which adjust the difficulty and pace of contents based on learners' performance, play a crucial role in this approach (Pane, Steiner, Baird, & Hamilton, 2017).

In the context of Africa, personalized learning has shown promise in addressing the diverse educational needs of students. For example, the Ulesson platform in Nigeria utilizes offline internet solutions to deliver personalized video lessons and quizzes through digital storage device (SD

cards) and dongles, enabling students to access high-quality educational content without incurring data costs (Okonkwo & Chukwu, 2020).

Education is a key driver of economic development, and enhancing access to quality education can have significant economic benefits for African countries. According to UNESCO (2022), investment in foundational learning alone could unlock up to $6.5 trillion in Africa's economy by 2030, underscoring the importance of educational initiatives in fostering economic growth. This projection highlights that educational initiatives such as improving literacy, numeracy, and access to quality schooling are not just social investments but also powerful economic strategies. When more people receive a solid education, they are better prepared for the workforce, more innovative, and more productive, all of which drive national income, reduce poverty, and stimulate economic growth. Therefore, the potential $6.5 trillion boost to Africa's economy underscores just how vital it is for governments and stakeholders to prioritize and invest in education as a foundational pillar of economic development.

Offline internet-based personalized remote learning can contribute to economic development by equipping learners with the skills and knowledge necessary to participate in the digital economy. By providing equitable access to education, these learning models can help reduce unemployment, promote entrepreneurship, and stimulate innovation across the continent (Aker & Ksoll, 2019).

Understanding the potential of offline internet-based personalized remote learning is crucial for policymakers, educators, and stakeholders aiming to enhance educational access and quality in Africa. By highlighting successful models and identifying best practices, this study can inform the development of scalable and sustainable educational interventions that address the unique challenges faced by African countries (UNESCO, 2022).

Furthermore, the study contributes to the broader discourse on leveraging technology for inclusive education and economic development, offering insights that can guide future investments and policy decisions in the education sector (World Bank, 2021).

Statement of Problem

Africa faces a persistent challenge in bridging the digital divide, as many communities, especially in rural and underserved areas, lack consistent access to reliable internet connectivity. This lack of infrastructure severely limits opportunities for remote learning, particularly personalized learning approaches that adapt to individual learner needs. Traditional online educational platforms often require continuous internet access, which is not feasible for large portions of the population. As a result, many learners are excluded from the benefits of modern educational technologies, leading to gaps in skills development, knowledge acquisition, and ultimately, economic empowerment. Offline internet-based personalized remote learning offers an innovative approach to overcoming these barriers by enabling access to tailored educational contents without the need for constant connectivity. However, challenges remain in the widespread adoption, integration, and effectiveness of such offline solutions in supporting skill development that can drive economic growth and reduce poverty across diverse African contexts. Addressing these challenges is crucial to harnessing the full potential of education technology in contributing to Africa's sustainable economic development.

Research Objectives

This study aims to explore the role of offline internet-based personalized remote learning in promoting economic development in Africa. The specific objectives are:

1. To examine the theoretical frameworks underpinning offline personalized learning.
2. To analyze the implementation of offline learning technologies in African contexts
3. To identify the challenges and opportunities associated with offline personalized learning
4. To assess the impact of offline learning on economic development indicators
5. To present case studies and best practices from successful implementations
6. To provide recommendations for scaling and sustaining offline personalized learning initiatives.

Theoretical Framework

Developing a theoretical framework for offline, personalized remote learning in Africa necessitates an understanding of several interconnected theories that address learning methodologies, technological integration, and the relationship between education and economic development.

Personalized learning focuses on tailoring educational experiences to individual learner's needs, preferences, and prior knowledge. Constructivist theories, such as those proposed by Piaget and Vygotsky, emphasize that learners construct knowledge through experiences and reflections. In the African context, integrating constructivist approaches with indigenous knowledge systems can enhance the relevance and effectiveness of personalized learning. For instance, the incorporation of African philosophical perspectives, like Ubuntu, which emphasizes communal relationships and mutual care, can inform the design of learning environments that are both personalized and culturally resonant.

The digital divide refers to the gap between individuals who have access to modern information and communication technologies and those who do not. In Africa, this divide is pronounced, particularly in rural areas. The Technology Acceptance Model (TAM) is often used to understand how users come to accept and use technology. Studies have shown that perceived ease of use and perceived usefulness are significant determinants of technology adoption in African educational contexts (Davis, 1989; Olatubosun et al., 2021; Boateng et al., 2016; Ifinedo, 2017). Addressing the digital divide involves not only providing access to technology but also ensuring that the technology is user-friendly and meets the specific needs of African learners.

Human capital theory posits that investments in education and training increase the productivity and efficiency of individuals, which in turn contributes to economic growth. In the African context, education is seen as a critical factor for economic development. Research indicates that higher levels of educational attainment are associated with improved economic outcomes in African countries. For example, a study analyzing the impact of education on economic growth in Sub-Saharan Africa found that education significantly contributes to economic development,

especially when aligned with the quality of institutions. By integrating these theories, a comprehensive framework can be developed to guide the implementation of offline, personalized remote learning initiatives in Africa. Such a framework would consider the individual learning needs of students, address technological accessibility challenges, and align educational outcomes with broader economic development goals.

Offline Internet-Based Learning Technologies

In regions with limited internet connectivity, particularly in parts of Africa, offline internet-based learning technologies have emerged as vital tools to facilitate education. These technologies enable access to educational content without the need for continuous internet connections, thereby bridging the digital divide and enhancing learning opportunities.

Offline Digital Libraries

Offline digital libraries store vast amounts of educational resources on local servers or devices, allowing users to access content without internet connectivity. The eGranary Digital Library, developed by the WiderNet Project, is a notable example. It provides access to millions of documents, including books, journals, and websites, by storing them on a local server that users can access via a local area network. This system has been implemented in various educational institutions across Africa, significantly enhancing access to information in low-bandwidth regions.

Offline-Enabled Web-Based E-Learning Platforms

To improve user experience in areas with limited connectivity, offline-enabled web-based e-learning platforms have been developed. These platforms allow learners to download educational contents when a connection is available and access it offline later. A study presented at the Institute of Electrical and Electronics Engineers IEEE Africon Conference discussed technical approaches to enhance user experience in web-based e-learning in Africa, emphasizing the importance of offline capabilities.

Portable Offline Servers and Devices

Portable offline servers, such as RACHEL (Remote Area Community Hotspot for Education and Learning) developed by World Possible, are compact devices preloaded with educational contents. These devices create a local Wireless Fidelity (Wi-Fi) hotspot, allowing students to connect using laptops, tablets, or smartphones to access materials like Khan Academy videos, Wikipedia articles, and other open educational resources without the need for internet access.

Solar-Powered Computer Labs

In areas lacking reliable electricity, solar-powered computer labs have been established to support offline learning. Organizations like Powering Potential have implemented Solar Powered Access to Raspberry Computing (SPARC) labs in Tanzanian schools. These labs utilize solar energy to power Raspberry Pi computers equipped with offline educational contents, thereby providing sustainable learning environments in remote regions.

Mobile Applications for Offline Learning

Mobile applications have been developed to facilitate offline learning. For instance, the African Storybook initiative offers a mobile app that allows users to download children's storybooks in multiple African languages for offline reading. This approach promotes literacy and provides access to culturally relevant materials without the need for continuous internet connectivity. These offline internet-based learning technologies play a crucial role in enhancing educational access and quality in regions with limited connectivity. By leveraging such innovations, educational institutions and organizations can provide learners with the resources they need to succeed, thereby contributing to broader socio-economic development.

Personalized Learning Strategies

Implementing personalized learning strategies in offline environments, particularly in regions with limited internet connectivity, requires innovative approaches that cater to individual learner needs while utilizing available resources. Research has demonstrated that personalized learning can enhance student engagement, motivation, and academic performance. For instance, a

study in Kenya found that personalized learning positively impacted mathematics performance among secondary school students (Ogwari et al., 2020).

Personalized learning involves customizing instruction to address the unique strengths, weaknesses, and interests of each student. In offline settings, this can be achieved through differentiated instruction, where educators design varied activities and materials to cater to diverse learning styles. For example, teachers can create learning stations with tasks of varying difficulty levels, allowing students to engage with contents that matches their proficiency. This approach has been shown to improve student outcomes by providing appropriate challenges and support (Alenezi, 2023).

In the absence of advanced technology, low-tech tools such as printed materials, flashcards, and physical manipulatives can be employed to facilitate personalized learning. Educators can develop individualized learning packets that students work on at their own pace, receiving feedback during one-on-one or small group sessions. This method allows for flexibility and ensures that learning is tailored to each student's progress.

Peer tutoring leverages the knowledge and skills of higher-achieving students to support their peers, fostering a collaborative learning environment. This strategy not only personalizes learning by addressing individual needs but also promotes social interaction and reinforces the tutor's understanding. Research indicates that peer tutoring can be effective in enhancing academic performance and engagement, particularly in resource-constrained settings (Sharma, 2024).

Regular assessments are crucial for identifying students' learning gaps and strengths. In offline contexts, educators can administer written quizzes, oral examinations, or practical tasks to gauge understanding. The data collected from these assessments can inform the development of targeted instructional strategies, ensuring that each student's specific needs are addressed.

Teaching students to be aware of their own learning processes—known as metacognition—enables them to take control of their learning. Strategies such as self-reflection journals, goal-setting activities, and self-assessment checklists can be implemented without the need for digital

tools. These practices help students monitor their progress and develop personalized strategies to overcome challenges.

By adopting these personalized learning strategies, educators can create inclusive and effective learning environments that cater to the diverse needs of students, even in offline settings. Such approaches are instrumental in enhancing educational outcomes and contributing to the broader goal of economic development through improved education.

Challenges and Opportunities

Implementing offline, personalized remote learning in Africa presents a complex interplay of challenges and opportunities that significantly impact educational outcomes and economic development.

Challenges

Infrastructure Deficiencies: A significant barrier is the lack of reliable electricity and internet connectivity in many African regions. A study by Nthenya et al. (2021) highlighted that limited access to Information and Communication Technologies (ICT) and internet services led to high dropout rates in online education during the COVID-19 pandemic. This underscores the necessity for substantial investments in infrastructure to support remote learning initiatives.

Socio-Economic Disparities: Economic challenges hinder access to necessary learning tools. Smith (2023) identified socio-economic inequality as a critical factor affecting the implementation of online distance learning in African countries. Students from low-income families often lack personal computers or mobile devices, limiting their participation in remote learning programs.

Digital Literacy Gaps: Both educators and learners may lack adequate digital skills, impeding the effective use of offline learning technologies. Osabwa (2022) reported that the sudden shift to remote learning during the pandemic exposed a general unpreparedness in terms of instructional technologies within African higher education institutions.

Content Relevance and Quality: Ensuring that offline educational content is culturally relevant and of high quality is essential. A study focusing on the transition to online learning in a South

African university emphasized the need for contextually appropriate materials to maintain student engagement and learning effectiveness.

Opportunities

Technological Innovations: The development of offline digital libraries and portable servers, such as the eGranary Digital Library, offers vast educational resources without the need for internet connectivity. These innovations can bridge the information gap in remote areas.

Policy Support and Investment: Governments and stakeholders can play a pivotal role by investing in infrastructure development, providing subsidies for educational devices, and implementing policies that promote equal access to education. Smith (2023) recommends prioritizing investments in infrastructure and collaborating with private organizations to support online learning platforms.

Community Engagement: Leveraging community resources and local knowledge can enhance the effectiveness of personalized learning. Engaging local educators and leaders in the development and dissemination of educational contents ensures cultural relevance and acceptance.

Capacity Building: Training programs aimed at improving digital literacy among educators and learners can maximize the benefits of offline learning technologies. Building these capacities is crucial for the successful implementation of personalized remote learning strategies.

Addressing these challenges while capitalizing on the opportunities require a collaborative approach involving policymakers, educational institutions, communities, and international partners. Such concerted efforts can lead to the successful implementation of offline, personalized remote learning in Africa, thereby contributing to the continent's economic development.

Impact on Economic Development

The implementation of offline, personalized remote learning in Africa holds significant potential for economic development. By enhancing educational access and quality, such initiatives can contribute to the development of human capital, which is a critical driver of economic growthEducation is a fundamental component of human capital development, equipping individuals with the skills and knowledge necessary for productive employment. In many African countries,

limited internet connectivity poses a barrier to accessing quality education. Offline internet systems, designed to store vast amounts of information for learning in low-resource regions, can mitigate this challenge by providing educational contents without the need for continuous internet access. This approach ensures that learners in remote areas can acquire essential skills, thereby enhancing their employability and potential to contribute to economic activities.

The digital divide—the gap between those with and without access to digital technologies—can exacerbate economic inequalities. Implementing offline learning technologies helps bridge this divide by offering educational opportunities to underserved populations. By improving access to education, these technologies can foster a more inclusive economy, enabling broader participation in various economic sectors.

Access to education through offline personalized learning can lead to increased productivity and innovation. Educated individuals are better equipped to adopt new technologies, improve processes, and drive innovation within their communities. For instance, entrepreneurs throughout the African continent are using generative AI to increase work productivity and expand economic opportunities. By integrating AI into educational tools, learners can receive personalized instruction, further enhancing learning outcomes and fostering a culture of innovation.

The COVID-19 pandemic highlighted the vulnerability of educational systems to disruptions, particularly in regions lacking robust online infrastructure. Offline learning solutions provide resilience against such disruptions, ensuring continuity of education during crises. Maintaining educational engagement during such times prevents learning losses and supports the sustained development of human capital, which is essential for long-term economic stability and growth.

Offline personalized remote learning initiatives in Africa can significantly impact economic development by developing human capital, bridging the digital divide, enhancing productivity and innovation, and ensuring educational continuity during disruptions. These efforts contribute to building a more inclusive and resilient economy across the continent.

Case Studies and Best Practices – Successful Examples of Offline Personalized Learning in Africa

Offline personalized learning has gained traction in Africa as a pragmatic solution to overcome the continent's persistent challenges of limited internet access, unreliable electricity, and high data costs. Various innovative models and programs have been implemented across African countries, showcasing effective use of offline internet-based personalized remote learning. This section highlights some prominent case studies and best practices demonstrating the potential and impact of these initiatives.

Ulesson Education, a Nigerian edtech startup, exemplifies the use of offline personalized learning through its unique delivery system that combines preloaded secure digital cards and dongles with interactive video lessons and quizzes. The platform targets secondary school students preparing for national exams, particularly in Science, Technology Engineering and Mathematics (STEM) subjects. By providing contents offline, Ulesson circumvents data affordability barriers, enabling students in rural and low-income areas to access high-quality educational contents (Okonkwo & Chukwu, 2020). The system's personalized approach adapts to individual learner performance, allowing students to review materials at their own pace, thus enhancing retention and engagement.

Ulesson has also incorporated adaptive learning algorithms that recommend lessons based on students' quiz results, further tailoring the learning path to individual needs. This innovation has reportedly improved student outcomes, with many users showing improved performance in mock and national exams (Nwaorgu, 2022). Ulesson's success highlights the feasibility of offline learning models in resource-constrained African contexts, offering scalable solutions adaptable to other countries.

Eneza Education is a mobile-based platform originally launched in Kenya, which provides educational contents via SMS, USSD, and offline applications, targeting primary and secondary school learners. Recognizing the constraints of data and internet connectivity, Eneza developed a

platform that works on basic mobile phones and low-data devices, allowing students to access lessons, quizzes, and revision materials offline or with minimal data use (Ng'ethe, 2021).

Eneza's personalized learning feature delivers quizzes that adapts to the learner's level, reinforcing concepts based on performance. In a pilot study, students using Eneza showed an average improvement of 20% in literacy and numeracy skills over six months (Kariuki&Kilonzo, 2019). Eneza's model has been adopted in several African countries, including Ghana and Tanzania, demonstrating cross-context adaptability. Its success underscores how mobile technology, even without full internet access, can facilitate personalized education in underserved regions.

Kolibri is an open-source educational platform developed by Learning Equality that enables offline access to a vast library of digital learning resources. It is designed for use in low-resource environments where internet connectivity is unreliable or absent. Kolibri allows educators and learners to download educational contents onto devices such as tablets or laptops, which can be shared across classrooms or communities without internet access (Learning Equality, 2023).

A notable deployment of Kolibri occurred in South African schools and rural communities, where teachers used it to deliver personalized contents aligned with national curricula. The platform's analytics enable educators to monitor learner progress and adjust instruction accordingly; supporting differentiated learning paths (Johnson et al., 2020). Kolibri has been integrated into government and NGO programs in countries like Rwanda and Zimbabwe, proving its scalability and effectiveness in diverse African settings.

Bridge International Academies operates a network of low-cost private schools using tablet-based lesson delivery systems that function offline after periodic synchronization. Their instructional model is built on scripted lesson plans and assessments tailored to each student's learning trajectory. Teachers use tablets loaded with these lessons, which can operate without internet, allowing consistent delivery in areas with poor connectivity (Kraft & Doepke, 2020).

Bridge's data-driven approach helps identify students who require additional support and adjusts instructional content accordingly, embodying personalized learning principles. Independent evaluations have reported improved literacy and numeracy outcomes among Bridge students compared to traditional public schools (Duflo, Dupas, & Kremer, 2015). The model's success in multiple African countries illustrates how offline digital tools can be embedded within school systems to enhance learning quality.

RACHEL is an offline server that hosts educational content and can be accessed locally via Wi-Fi in remote locations. Used widely by NGOs and educational programs across Africa, RACHEL allows communities with no internet connectivity to access a vast repository of learning resources, including textbooks, videos, and interactive lessons (Erdmann, 2019).

In Ethiopia and Uganda, for example, RACHEL has been deployed in community learning centers and schools, where it supports personalized learning by enabling learners to navigate content independently or with minimal facilitation. Reports indicate increased learner engagement and self-directed study habits (Munyua, et al., 2020). RACHEL's flexibility to be updated and customized for local languages and curricula makes it a best practice example of offline learning implementation.

Summary of Best Practices

Contextual Adaptation: Successful offline personalized learning initiatives tailor content and technology to local infrastructure constraints and learner needs (Okonkwo & Chukwu, 2020; Learning Equality, 2023).

Cost-Effectiveness: Models such as Ulesson and Eneza demonstrate the importance of minimizing data costs and device requirements to expand access (Adie et al., 2021).

Scalability and Sustainability: Platforms like Kolibri and Bridge show how offline digital education can scale across regions and integrate with existing educational systems (Johnson et al., 2020; Kraft &Doepke, 2020).

Data-Driven Personalization: Leveraging learner performance data to tailor content enhances engagement and improves outcomes (Pane et al., 2017; Duflo et al., 2015).

Community Involvement: Programs using RACHEL illustrate the value of community-based access points and localized content to promote self-directed learning (Munyua et al., 2020).

Offline internet models can provide meaningful and equitable educational opportunities even in the absence of continuous internet connectivity enabling personalized learning for economic emancipation

Recommendations and Future Prospects

Advancing offline personalized remote learning in Africa necessitates strategic initiatives to overcome existing challenges and leverage emerging opportunities. The following recommendations aim to enhance the effectiveness and sustainability of such educational models:

1. Investing in robust infrastructure is crucial to support offline learning technologies. This includes expanding access to electricity and providing affordable digital devices to learners in remote areas. Governments and development partners should prioritize investments in electricity access (including solar solutions), affordable devices, and local offline servers to support remote learning in low-resource areas. These infrastructure upgrades should be tailored for offline deployment rather than relying solely on internet expansion.

2. Training educators to effectively utilize offline educational tools is essential. Professional development programs should focus on integrating interactive technologies into teaching practices. Continuous professional development is essential for equipping educators with the skills to implement offline personalized learning effectively. Training should focus on integrating technology with pedagogy, managing differentiated instruction, and creating individualized learning materials.

3. Creating educational materials that reflect local languages and cultural contexts enhances learner engagement and comprehension. This approach ensures that content is accessible and meaningful to

diverse student populations. Partnerships with local educators, curriculum boards, and content creators can ensure alignment with national standards and cultural values.

4. Governments should establish policies that promote the adoption of offline learning solutions and provide support for necessary infrastructure and training. Collaborations between public and private sectors can mobilize resources and expertise to scale effective educational models.

5. AI has the potential to transform learning environments by providing personalized educational experiences. AI-powered personalized learning, even in offline formats, can enhance engagement through adaptive feedback and learner analytics. Tools like preloaded AI tutors or locally hosted learning analytics engines should be explored, particularly in secondary and vocational education. Looking ahead, the integration of AI and other emerging technologies into offline learning platforms offers promising avenues for enhancing educational outcomes. Innovations such as AI-powered personalized tutoring programs, like SkillBridge in Ethiopia, demonstrate the potential to improve learning experiences and address educational challenges.

By implementing these recommendations, African nations can strengthen their educational systems, making them more resilient and capable of providing quality education to all learners, regardless of connectivity constraints.

Conclusion

In summary, offline, internet-independent personalized remote learning emerges as a viable solution to overcome the severe connectivity challenges that have long impeded educational access in many African regions. By leveraging preloaded digital contents, adaptive learning strategies, and localized instructional materials, these models can provide meaningful and equitable educational opportunities even in the absence of continuous internet connectivity.

Offline learning technologies are essential to bridge the gap between urban and rural educational opportunities, allowing students from disadvantaged backgrounds to access quality educational contents without incurring high data costs or suffering from infrastructure deficiencies.

By providing tailored learning experiences, these models contribute to the development of critical skills and competencies, ultimately enhancing labor market readiness and supporting inclusive economic growth across the continent.

Successful examples from platforms like Ulesson, Eneza Education, Kolibri, Bridge International Academies, and RACHEL highlight the potential of scalable offline solutions. These case studies underline the importance of adaptable, low-cost, and contextually relevant technologies in improving learning outcomes.

The long-term success of offline personalized learning depends on targeted investments in digital and power infrastructure, comprehensive teacher training, culturally adapted content, and robust public–private partnerships. Furthermore, integrating emerging technologies such as artificial intelligence can further enhance personalization and learner engagement.

Overall, this review advocates for a holistic approach where policymakers, educators, and technology developers collaborate to create resilient, scalable, and sustainable offline educational systems. With such concerted efforts, offline personalized learning not only represents a critical step in mitigating the digital divide but also holds the promise of catalyzing broader socio-economic development in Africa.

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