

Designing a Sustainable Digital Learning Delivery Model for Resource-Constrained School Settings

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Abstract

Digital learning has become an essential component of modern education; however, many schools in resource-constrained settings continue to face significant barriers, including unreliable electricity, limited internet connectivity, inadequate digital devices, shortages of instructional materials, and limited opportunities for teacher professional development. These challenges limit equitable access to quality education and reduce the effectiveness of many existing educational technology initiatives. The purpose of this proposed study is to develop a sustainable digital learning delivery model that supports teaching and learning in resource-constrained school settings. The study will employ a qualitative case study approach to explore the experiences, perspectives, and recommendations of teachers and students in selected schools in Tigray, Ethiopia. Data will be collected through semi-structured teacher interviews, student focus group discussions, classroom observations, and reviews of relevant instructional materials. The collected data will be analyzed using thematic analysis to identify common patterns, implementation challenges, and essential design components for sustainable digital learning. Based on the literature review, the anticipated findings are expected to support a comprehensive digital learning delivery model built upon three complementary pillars: teacher empowerment through professional development and instructional support, learner-centered learning that promotes independent, collaborative, and interactive learning experiences, and sustainable educational technology that emphasizes affordable Android-based devices, offline-first learning applications, curriculum-aligned instructional resources, reliable power solutions, and sustainable content management. The proposed model is expected to provide educators, instructional designers, schools, governments, and educational organizations with a practical and scalable framework for expanding equitable access to quality education while establishing a

foundation for future quantitative and mixed-methods research evaluating the effectiveness of the proposed model.

Keywords

Keywords: sustainable digital learning; teacher empowerment; learner-centered learning; educational technology; offline learning; digital equity; resource-constrained schools

Introduction

The integration of educational technology has created new opportunities to improve teaching and learning by increasing access to instructional resources, supporting learner engagement, and expanding educational opportunities. Despite these advances, many schools in resource-constrained settings continue to face significant barriers, including limited internet connectivity, unreliable electricity, inadequate digital devices, shortages of instructional materials, and limited opportunities for teacher professional development. These challenges restrict equitable access to quality digital learning and highlight the need for practical, sustainable, and context-appropriate educational solutions. The purpose of this proposed study is to develop a sustainable digital learning delivery model that supports teaching and learning in resource-constrained school settings. The study seeks to identify the essential components of such a model by exploring the experiences and perspectives of teachers and students in selected schools in Tigray, Ethiopia. The proposed model is expected to integrate teacher empowerment, learner-centered learning, and sustainable educational technology into a comprehensive framework that promotes equitable access to quality education. The following literature review examines current research related to digital equity, technology integration, teacher preparation, instructional practices, and sustainable digital learning to establish the foundation for the proposed study.

Literature Review

Proposed Research Topic

A Model for Delivering Sustainable Digital Learning in Resource-Constrained School Settings

Proposed Research Question

How can a sustainable digital learning delivery model be designed and implemented to support teaching and learning in resource-constrained school settings?

Operational Definition of Sustainable Digital Learning Delivery:

For this study, sustainable digital learning delivery refers to an educational model that integrates teacher empowerment through professional development and instructional support, learner-centered learning that promotes independent, collaborative, and interactive learning experiences, and sustainable educational technology that includes affordable digital devices, offline-capable learning resources, curriculum-aligned instructional materials, classroom organization, reliable power solutions, periodic content updating, and long-term maintenance to support continuous teaching and learning in resource-constrained school settings.

Background and Rationale

Educational technology has become an important strategy for expanding access to quality education and improving teaching and learning. However, many schools in resource-constrained settings continue to experience significant barriers, including unreliable electricity, limited internet connectivity, shortages of digital devices, inadequate instructional materials, and insufficient opportunities for teacher professional development. Previous research consistently demonstrates that technology alone does not improve educational outcomes. Instead, meaningful digital learning depends on effective instructional design, teacher capacity, learner engagement, supportive leadership, curriculum alignment, and sustainable implementation. Building upon this

evidence, the proposed study seeks to develop a sustainable digital learning delivery model that integrates teacher empowerment, learner-centered learning, and sustainable educational technology to improve equitable access to quality education in resource-constrained school settings.

Selected Literature

The following five peer-reviewed studies were selected because they directly relate to the proposed research question and collectively provide theoretical, empirical, and practical perspectives on digital learning in resource-constrained educational settings.

Current State of Knowledge

Warschauer and Matuchniak (2010) established an important theoretical foundation for digital equity by demonstrating that meaningful educational outcomes depend on three interconnected dimensions: access, use, and learning outcomes. Mustafa et al. (2024) synthesized evidence from rural schools worldwide and concluded that successful technology integration requires coordinated action at the macro, meso, and micro levels, including supportive educational policies, school leadership, teacher preparation, and classroom implementation. Johnston and Ksoll (2022) demonstrated through a randomized controlled trial in Ghana that interactive technology-supported instruction significantly improved student learning when combined with effective teaching and classroom facilitation. Kaumba et al. (2021) reported that rural schools in Zambia addressed resource limitations through collaboration, creative ICT use, and locally appropriate instructional practices. Similarly, Shambare and Simuja (2024) concluded that teachers' technological pedagogical content knowledge (TPACK), continuous professional development, and supportive school cultures are essential for successful technology integration in rural South African schools. Collectively, these studies demonstrate that effective digital

learning depends upon the interaction of educational technology, pedagogy, teacher capacity, learner engagement, and sustainable implementation rather than technological access alone.

Synthesis of Common Trends

Across the five studies, digital learning is consistently presented as a comprehensive educational system rather than simply the availability of hardware or internet connectivity. Common themes include digital equity, teacher professional development, instructional design, learner engagement, curriculum alignment, leadership support, and sustainable implementation.

Although the studies differ in methodology and educational context, they complement one another by demonstrating that successful technology integration requires coordinated support from policymakers, schools, teachers, students, and communities.

Taken together, the literature suggests that meaningful digital learning should integrate appropriate technology with effective pedagogy and sustainable implementation rather than relying on technological solutions alone. These findings strongly support the need for a practical framework that combines teacher empowerment, learner-centered instructional practices, and sustainable educational technology within a single delivery model suitable for resource-constrained school settings.

Knowledge Gaps

Although previous research has significantly advanced understanding of digital equity, teacher professional development, instructional effectiveness, and technology integration, important gaps remain. Existing studies have largely examined individual aspects of digital learning without proposing a comprehensive delivery model that integrates teacher empowerment, learner-centered learning, and sustainable educational technology within a single implementation framework. Limited attention has also been given to offline-first instructional design, shared-

device classroom organization, affordable Android-based learning, interactive curriculum-aligned instructional materials, sustainable content updating, renewable power solutions, and the combined perspectives of teachers and students in resource-constrained school settings.

Addressing these gaps provides the rationale for the proposed study and supports the development of a practical sustainable digital learning delivery model that responds to the educational realities of resource-constrained schools.

Method

This proposed study will employ a qualitative case study design to explore the essential components of a sustainable digital learning delivery model for resource-constrained school settings. A qualitative approach is appropriate because the study seeks to understand the experiences, perspectives, and practical recommendations of teachers and students rather than test a hypothesis or measure statistical relationships among variables. The study aims to generate rich descriptive information that can inform the design of a practical, context-appropriate, and sustainable digital learning delivery model.

Research Design

A qualitative case study design will be used to examine digital teaching and learning practices within selected resource-constrained schools in Tigray, Ethiopia. This design is appropriate because it allows the researcher to investigate the phenomenon within its natural educational setting while considering the social, technological, and instructional factors that influence digital learning. The case study approach also supports the use of multiple sources of evidence to develop a comprehensive understanding of current practices, implementation challenges, and opportunities for improvement.

Participants

Participants will include approximately 5–8 teachers and 6–10 students from selected resource-constrained schools in Tigray, Ethiopia. Teachers will provide perspectives on instructional practices, technology integration, classroom organization, and professional development needs, while students will share their experiences with learning resources, digital access, collaborative learning, and learner-centered instructional approaches. Participants will be selected through purposive sampling using the researcher's professional network and participating schools.

Participation will be voluntary, and informed consent will be obtained from all participants. For students under 18 years of age, parental or guardian consent and school approval will also be obtained before participation.

Data Collection

Data will be collected through semi-structured teacher interviews, student focus group discussions, classroom observations, and reviews of relevant instructional materials such as lesson plans and locally developed digital learning resources. Teacher interviews will explore instructional practices, implementation challenges, professional development needs, and recommendations for sustainable digital learning. Student focus group discussions will examine learning experiences, preferred learning resources, collaborative learning practices, and access to digital technologies. Classroom observations and instructional documents will provide additional contextual information and allow the researcher to compare participants' perspectives with actual classroom practices. The use of multiple data sources is appropriate because it enables data triangulation, increasing the credibility and depth of the findings.

Data Analysis

The collected data will be analyzed using thematic analysis. Interview and focus group recordings will be transcribed and reviewed multiple times to become familiar with the data. Meaningful statements will be assigned descriptive codes, which will then be grouped into categories representing common experiences, challenges, and recommendations. Coding and theme development will be conducted manually using Microsoft Word and Microsoft Excel to organize participants' responses into codes, categories, and themes. The resulting themes will be compared across teacher and student responses to identify areas of agreement, complementary perspectives, and context-specific differences that contribute to the development of the proposed sustainable digital learning delivery model. To enhance the trustworthiness of the study, data triangulation, a consistent interview protocol, systematic coding procedures, and careful documentation of the analysis process will be used to strengthen credibility and dependability.

Ethical Considerations

Participation in the study will be voluntary, and participants will be informed of the purpose of the research before data collection begins. Confidentiality will be maintained by using anonymous identification codes rather than participants' names or school names. All interview recordings, transcripts, and research materials will be stored securely and used solely for academic purposes. Participants will have the right to decline participation or withdraw from the study at any time without penalty. Appropriate school approval and parental or guardian consent will be obtained for student participants where required.

Anticipated Results

Based on the literature review and the proposed qualitative data collection, the study is expected to identify the essential components of a sustainable digital learning delivery model that responds to the educational realities of resource-constrained school settings. The anticipated findings are expected to demonstrate that sustainable digital learning requires the integration of teacher empowerment, learner-centered learning, and sustainable educational technology rather than relying solely on the availability of digital devices or internet access.

Teacher Empowerment

The study is expected to find that teachers play a central role in the successful implementation of digital learning. Participants are anticipated to identify the need for continuous professional development, instructional support, and practical training in integrating digital resources into classroom teaching. Teachers are also expected to emphasize that digital learning should complement rather than replace classroom instruction, with teachers serving as facilitators who guide students in using technology effectively. In addition, the findings may highlight the importance of supportive school leadership, ongoing technical assistance, and collaboration among teachers to sustain digital learning initiatives.

Learner-Centered Learning

Teachers and students are expected to identify learner-centered instructional practices as essential components of sustainable digital learning. Students are anticipated to value opportunities for independent, self-paced learning using interactive digital resources both inside and outside the classroom. Participants may also emphasize the importance of collaborative learning, where students work together in small groups when sharing limited digital devices. Interactive learning materials such as videos, practice exercises, quizzes, simulations, and immediate feedback are

expected to be preferred over passive reading materials alone. Furthermore, affordable Android phones, which are available in many households, are expected to provide students with greater access to learning resources beyond the school environment.

Sustainable Educational Technology

The anticipated findings are expected to demonstrate that technology solutions must be affordable, practical, and sustainable within local educational contexts. Participants are likely to recommend an offline-first digital learning application capable of storing curriculum-aligned instructional materials locally while allowing content updates whenever internet connectivity becomes available. The study is also expected to support a one-computer-to-many classroom model, in which a single computer connected to a projector or television enables whole-class instruction when individual devices are unavailable. Additional anticipated recommendations include reliable power solutions such as solar charging systems, locally relevant instructional content, curriculum alignment, local-language support, sustainable content updating, technical support, and long-term maintenance strategies.

Overall, the anticipated findings are expected to support the development of a comprehensive sustainable digital learning delivery model that integrates teacher empowerment, learner-centered pedagogy, and sustainable educational technology into a practical framework for improving equitable access to quality education in resource-constrained school settings. The proposed model is expected to provide practical guidance for educators, instructional designers, school leaders, policymakers, and educational organizations seeking scalable and context-appropriate digital learning solutions.

Anticipated Discussion

The anticipated findings are expected to confirm several themes identified in previous research regarding sustainable digital learning in resource-constrained school settings. Consistent with Warschauer and Matuchniak (2010), the proposed study is expected to reinforce the importance of digital equity by demonstrating that meaningful educational outcomes depend not only on access to technology but also on effective instructional practices and learner engagement. The anticipated findings are also expected to support Mustafa et al. (2024), who emphasized that successful technology integration requires coordinated efforts at the macro, meso, and micro levels. Similarly, the expected results are anticipated to align with Johnston and Ksoll (2022), Kaumba et al. (2021), and Shambare and Simuja (2024) by highlighting the importance of teacher professional development, classroom facilitation, curriculum alignment, supportive school leadership, and context-appropriate technology implementation. Collectively, these anticipated findings are expected to reinforce previous evidence that sustainable digital learning depends on the integration of technology, pedagogy, and institutional support rather than technology alone.

Differing from previous findings, the proposed study is expected to extend the existing literature by developing a comprehensive sustainable digital learning delivery model that integrates three complementary pillars: teacher empowerment, learner-centered learning, and sustainable educational technology within a single implementation framework. While previous studies have generally examined technology integration, digital equity, teacher knowledge, or instructional effectiveness separately, the anticipated findings are expected to demonstrate how these elements can be combined into a practical model specifically designed for resource-constrained school

settings. The study is also expected to contribute additional perspectives by incorporating the experiences of both teachers and students, emphasizing offline-first instructional design, affordable Android-based learning, one-computer-to-many classroom instruction, shared-device collaborative learning, and sustainable content management. These anticipated contributions are expected to extend the current body of knowledge by providing a practical framework that educators, instructional designers, policymakers, and educational organizations may adapt to improve equitable access to quality education in resource-constrained schools.

Probable Conclusion

This proposed study seeks to develop a sustainable digital learning delivery model that supports teaching and learning in resource-constrained school settings by exploring the experiences and perspectives of teachers and students. The study is expected to demonstrate that sustainable digital learning extends beyond the provision of digital technologies alone and instead requires the integration of effective pedagogy, teacher support, learner engagement, and sustainable implementation strategies. The anticipated findings are expected to identify the essential components of a practical delivery model that combines teacher empowerment through professional development and instructional support, learner-centered learning that promotes independent, collaborative, and interactive learning experiences, and sustainable educational technology that emphasizes affordable offline-first solutions, curriculum-aligned instructional materials, reliable power sources, and long-term content management. Together, these three interconnected pillars are expected to provide a practical framework for improving equitable access to quality education in resource-constrained school settings.

The proposed model is expected to contribute to educational practice by providing educators, instructional designers, school leaders, policymakers, and educational organizations with a

context-responsive framework for planning and implementing sustainable digital learning initiatives. Because this is an exploratory qualitative proposal, the anticipated findings will be limited to a relatively small number of participants within selected schools in Tigray, Ethiopia and therefore may not be generalizable to all educational settings. Nevertheless, the study is expected to provide valuable contextual insights and a foundation for future research. Future studies may evaluate the effectiveness of the proposed model using quantitative or mixed-methods approaches, larger and more diverse participant populations, and implementation across different regions and educational contexts. By integrating teacher empowerment, learner-centered learning, and sustainable educational technology into a single framework, the proposed study aims to contribute to ongoing efforts to improve equitable and sustainable digital learning opportunities for schools with limited educational resources.

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Appendices

The following appendices contain the proposed research instruments and data analysis procedures that would be used if this study were conducted. These materials are included to demonstrate the feasibility of the proposed qualitative case study and to provide transparency regarding the planned data collection and analysis methods.

Appendix A – Preliminary Teacher Questionnaire

<https://drive.google.com/file/d/1on5-hMr2oQGSme9i9DkyHweh2qAB9nSv/view?usp=sharing>

Appendix B – Preliminary Student Questionnaire

https://drive.google.com/file/d/1_IpqlhaiIOKNRft6NbxObjgiAYga3_aW/view?usp=sharing

Appendix C – Simple Thematic Analysis Plan

<https://drive.google.com/file/d/1WzvJLXOXhiw1Q5jfnXO87c7mms-dfcFw/view?usp=sharing>

Declaration of AI Use

This paper was developed with support from AI tools. ChatGPT (OpenAI, 2024) was used to assist with grammar refinement, sentence structure, organization, and clarity of instructional design content. The ideas, instructional goals, analysis, and project direction were developed by the student.