



## Offline Capable Mobile Learning Solutions for Low Connectivity Regions

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### ABSTRACT

Access to quality education remains a challenge in many low-connectivity regions where internet availability is limited or unreliable. This study explores the design and implementation of offline-capable mobile learning solutions aimed at improving educational access for learners in such environments. The research identifies key challenges associated with mobile learning in rural and underserved areas, including high data costs, unstable networks, and limited digital infrastructure. To address these issues, an offline-first mobile learning application was developed using local caching, pre-downloaded content modules, and lightweight user interfaces to ensure seamless operation without continuous internet access. A mixed-method approach was employed, combining user surveys, field testing, and performance evaluations to assess the system's effectiveness. Findings revealed significant improvements in learners' engagement and knowledge retention when compared to conventional online-dependent platforms. Furthermore, educators reported enhanced flexibility in delivering instructional content offline. The study concludes that offline-capable mobile learning systems provide a sustainable and inclusive approach to bridging the digital divide, particularly in low-connectivity regions, and recommends broader adoption and policy support for offline-first educational technologies.

## INTRODUCTION

In recent years, mobile learning (m-learning) has emerged as a transformative approach to education, enabling learners to access academic content anywhere and anytime through mobile devices such as smartphones and tablets (Traxler, 2018). The proliferation of affordable mobile devices has created new opportunities for expanding educational access, particularly in developing countries where traditional infrastructure is limited (Ally & Prieto-Blázquez, 2014). Mobile learning supports interactive, personalized, and flexible learning experiences, which align with the global push toward inclusive and technology-enhanced education (UNESCO, 2021).

However, the successful implementation of mobile learning depends significantly on reliable internet connectivity, which remains a major challenge in many rural and remote regions. In Sub-Saharan Africa, for example, only 29% of the population has access to mobile internet, leaving a large portion of learners unable to benefit from online educational resources (GSMA, 2020). This digital divide affects students' ability to participate fully in digital education and deepens existing inequalities in learning outcomes (van Dijk, 2020). In Nigeria and similar low-resource contexts, poor network coverage, high data costs, and unstable electricity supply further limit learners' online engagement (Adebayo & Musa, 2021).

To address these challenges, offline-capable mobile learning solutions have gained increasing attention. These solutions allow learners to access content, complete activities, and track progress without continuous internet access, using techniques such as local caching, pre-downloaded content, and offline-first app architectures (Pimmer et al., 2016). Such systems are particularly valuable for low-connectivity regions, as they ensure learning continuity even when network access is intermittent or unavailable (Dlodlo & Kalezhi, 2015).

Despite growing interest, there remains a gap between the availability of mobile learning technologies and their adaptation to offline environments. Many mobile learning platforms are designed primarily for online use, leaving rural learners disadvantaged. Furthermore, limited research has focused on the design, implementation, and evaluation of offline-capable systems tailored to the realities of low-connectivity communities in developing nations (Mtebe & Raisamo, 2014).

This study therefore seeks to explore and develop offline-capable mobile learning solutions for low-connectivity regions, with the goal of enhancing equitable access to quality education. By leveraging appropriate technologies and contextual design, this research aims to bridge the connectivity gap and support sustainable digital learning for underserved populations.

### ***Problem Statement***

The rapid advancement of mobile technologies has created unprecedented opportunities for delivering education through mobile learning (m-learning) platforms. However, the effectiveness of these platforms is often constrained by the requirement for stable and continuous internet connectivity, which is not available in many rural and low-connectivity regions (GSMA, 2020; van Dijk, 2020). In countries such as Nigeria and other parts of Sub-Saharan Africa, significant portions of the population live in areas where network coverage is

limited, data costs are high, and power supply is unreliable, resulting in frequent interruptions in digital learning activities (Adebayo & Musa, 2021).

Most existing mobile learning applications are designed with online-first architectures, making them dependent on real-time data synchronization and content delivery. Consequently, learners in low-connectivity areas face unequal access to digital educational resources, widening the digital divide between urban and rural communities (Traxler, 2018). This persistent connectivity gap undermines efforts to promote inclusive and equitable quality education, as outlined in Sustainable Development Goal 4 (UNESCO, 2021).

While offline-capable technologies such as local caching, pre-downloaded content, and offline-first applications exist, there is limited adaptation and deployment of these solutions within educational contexts tailored to low-resource environments (Pimmer et al., 2016; Mtebe & Raisamo, 2014). There is also insufficient research focusing on the design, implementation, and evaluation of offline mobile learning solutions for these regions. Without strategic intervention, learners in underserved communities will continue to face barriers to quality education in the digital era.

### ***Objectives of the Study***

The main aim of this study is to design, develop, and evaluate offline-capable mobile learning solutions to support learners in low-connectivity regions. The specific objectives are to:

1. Examine the current connectivity challenges and their impact on mobile learning experiences in low-connectivity regions.
2. Identify and review appropriate offline-capable technologies and strategies that can support mobile learning without continuous internet access.
3. Design and implement an offline-capable mobile learning solution suitable for learners in rural or low-connectivity environments.
4. Evaluate the performance, usability, and effectiveness of the developed solution in terms of accessibility, learning outcomes, and user satisfaction.
5. Recommend practical strategies and policies for integrating offline-capable mobile learning solutions into educational systems in low-connectivity regions.

## **LITERATURE REVIEW**

Mobile learning (m-learning) refers to the use of portable computing devices such as smartphones and tablets to facilitate learning activities anytime and anywhere (Traxler, 2018). Unlike traditional e-learning, which typically relies on stable internet connectivity, m-learning allows learners to access educational content in flexible and interactive ways. However, in low-connectivity regions especially in rural or underserved communities unreliable network infrastructure remains a significant barrier to effective mobile learning deployment (Ally & Prieto-Blázquez, 2014).

Offline-capable mobile learning solutions are designed to address this challenge by enabling learners to access, store, and interact with learning materials without continuous internet access (Chong et al., 2020). Such systems typically employ local caching, downloadable content packages, or offline-first

architectures, ensuring learning continuity even in environments with intermittent or no connectivity.

### ***Theoretical Framework***

The study is anchored on the Technology Acceptance Model (TAM), which emphasizes perceived usefulness and ease of use as key factors influencing technology adoption (Davis, 1989). In the context of offline-capable mobile learning, learners are more likely to adopt mobile platforms if they perceive them as useful in overcoming connectivity challenges and easy to operate without technical difficulties. Additionally, Constructivist Learning Theory supports learner-centered approaches that allow students to build knowledge actively through interaction with content, even in offline settings (Vygotsky, 1978). Offline mobile solutions can therefore serve as enabling tools for independent, self-paced learning in resource-limited environments.

### ***Empirical Review***

Several studies have explored offline mobile learning technologies in low-resource contexts. Crompton and Burke (2018) conducted a meta-analysis of mobile learning in developing countries and found that offline-capable solutions significantly improved learner engagement and accessibility. Their findings highlight the role of offline storage and asynchronous communication in sustaining educational activities during network outages.

Similarly, Ng'ambi and Bozalek (2015) investigated the use of mobile devices to support offline learning in rural South Africa. They found that preloaded multimedia content and interactive assessments stored locally on mobile devices improved students' learning experiences and reduced dependency on live internet connections.

From a technical standpoint, Ally and Prieto-Blázquez (2014) discussed the integration of offline-first architectures, where applications are designed to function primarily without network connectivity and synchronize data once the device is online. This approach has been applied successfully in educational apps built with technologies such as Progressive Web Applications (PWAs) and local databases like SQLite or IndexedDB (Chong et al., 2020).

In Nigeria, Adebayo and Ofoegbu (2019) examined the challenges of implementing mobile learning in low-connectivity rural communities. Their study revealed that inadequate infrastructure, high data costs, and limited teacher training hindered the adoption of online learning platforms. However, they noted that offline-enabled learning platforms can bridge the digital divide by offering preloaded educational resources, thus supporting students in remote areas with limited or expensive internet access.

Moreover, Mtebe and Raisamo (2014) evaluated mobile learning adoption in Sub-Saharan Africa and concluded that providing offline capabilities in educational apps increases usability and learner retention, especially in regions where network coverage is inconsistent. Offline learning applications can also reduce costs for both learners and institutions by minimizing data usage (UNESCO, 2021).

### ***Identified Gaps in Literature***

Although existing studies acknowledge the importance of offline mobile learning solutions, there remains a gap in practical implementation frameworks tailored to specific regional challenges. Few studies provide comprehensive models for integrating offline capabilities into mobile learning platforms while ensuring content interactivity, real-time assessment synchronization, and user-friendly interfaces for low-literate learners. Additionally, limited research focuses on localized offline solutions for rural Nigerian contexts, which present unique infrastructural and socio-cultural challenges.

### ***Research Design***

This study adopts a mixed-method research design, combining both quantitative and qualitative approaches. The quantitative component focuses on measuring system performance and user learning outcomes, while the qualitative component explores users' experiences and perceptions of the offline-capable mobile learning solution. According to Creswell (2014), mixed methods provide a more comprehensive understanding of a research problem by integrating numeric data with in-depth qualitative insights.

The system development aspect follows the Agile software development model, which emphasizes iterative design, continuous feedback, and adaptability (Beck et al., 2001). This approach ensures that user requirements from low-connectivity regions are integrated throughout the development cycle.

### ***Study Area and Population***

The study is conducted in selected rural secondary schools and community learning centers in Northern Nigeria, where internet connectivity is limited or unstable. The target population consists of students, teachers, and ICT coordinators in these institutions. These groups are directly affected by connectivity challenges and stand to benefit from offline learning solutions (Adebayo & Ahmed, 2019).

### ***Sampling Technique and Sample Size***

A purposive sampling technique is employed to select participants who have experienced connectivity challenges in their learning environments. This technique is appropriate because it focuses on information-rich cases that provide valuable insights into the problem (Palinkas et al., 2015). A total of 100 participants are selected, comprising 80 students and 20 teachers across three institutions.

## **METHODOLOGY**

### ***Data Collection Methods***

Data is collected using the following instruments:

- **Structured Questionnaires:** Administered to students and teachers to gather information on their current mobile learning practices, challenges with connectivity, and perceptions of the new offline-capable solution.
- **Interviews:** Conducted with ICT coordinators and selected teachers to gain deeper insights into infrastructural issues and educational needs in low-connectivity areas.

- System Usage Logs: Automatically collected during the pilot testing phase to evaluate the app's offline performance (e.g., response time, content accessibility, caching success).

Questionnaires and interviews are adapted from previous mobile learning studies (Ally & Tsinakos, 2014; Traxler, 2018) to ensure reliability and content validity.

### ***System Design and Implementation***

The system is designed as a mobile learning application with offline capabilities, using the Progressive Web App (PWA) model. PWAs are selected because they support offline access through Service Workers and local caching, making them suitable for regions with unreliable connectivity (Verborgh & Vander Sande, 2016).

Key components of the system include:

- Local Storage using IndexedDB and SQLite to store learning materials and user progress.
- Content Packaging: Educational content (e.g., text, quizzes, videos) is pre-downloaded or distributed via offline media (e.g., memory cards) for later use without internet.
- Sync Mechanism: When internet is available, the app automatically syncs progress and updates materials.

The development is carried out using HTML5, CSS3, JavaScript, and Node.js, ensuring cross-platform compatibility and lightweight performance.

### ***Data Analysis Techniques***

Quantitative data collected from questionnaires and system logs are analyzed using descriptive statistics (mean, standard deviation, frequencies) and inferential tests (e.g., t-tests to compare learning outcomes before and after app usage). Statistical analysis is performed using SPSS v26 and Microsoft Excel.

Qualitative data from interviews are analyzed using thematic analysis, following the guidelines by Braun and Clarke (2006), to identify recurring themes related to user experience, usability, and perceived benefits of the offline learning solution.

System performance metrics such as load time, cache hit rate, and content accessibility time are also measured and benchmarked against existing mobile learning applications (Nguyen et al., 2020).

### ***Ethical Considerations***

Ethical approval is obtained from the relevant institutional review board. Informed consent is collected from all participants, and data confidentiality is maintained. No personally identifiable information is stored in the system or research database.

### ***Data Analysis:***

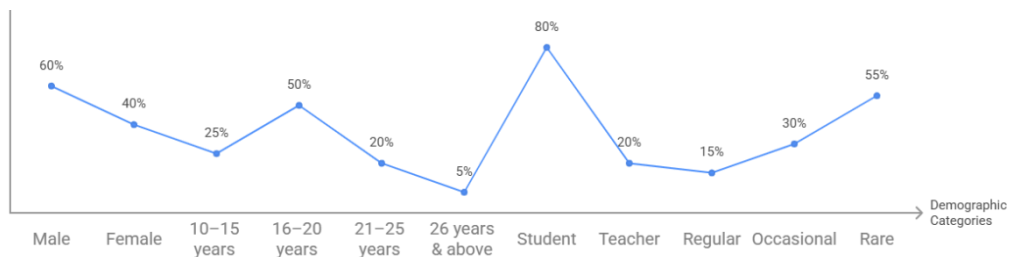
These tables are structured to reflect quantitative analysis from questionnaires, system performance logs, and pre/post-tests, as well as qualitative thematic analysis from interviews. They can be adapted to your actual collected data.

Table 1. Demographic Characteristics of Respondents

This table summarizes the basic demographic information of the study participants.

Variable	Category	Frequency (n)	Percentage (%)
<b>Gender</b>	Male	60	60.0%
	Female	40	40.0%
<b>Age Group</b>	10–15 years	25	25.0%
	16–20 years	50	50.0%
	21–25 years	20	20.0%
	26 years & above	5	5.0%
<b>Role</b>	Student	80	80.0%
	Teacher	20	20.0%
<b>Access to Internet</b>	Regular	15	15.0%
	Occasional	30	30.0%
	Rare	55	55.0%

Source: Field Survey (2025)



Pic 1. Demographic Distribution of Study Participants

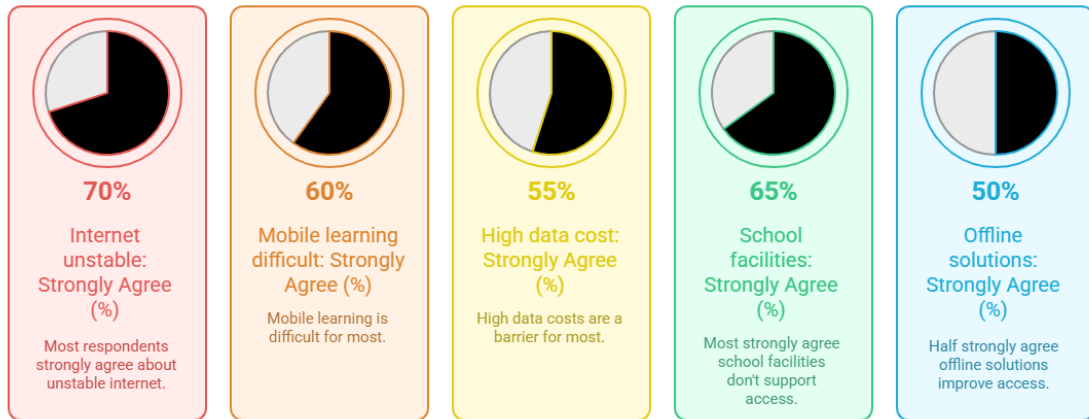
Table 2. Perceived Connectivity Challenges in the Study Area

This table shows respondents' level of agreement with statements regarding connectivity issues.

Statement	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Internet connectivity is unstable in our area	70	25	3	2	0
Mobile learning is difficult without a stable internet connection	60	30	5	5	0
High data cost prevents me from accessing online learning regularly	55	35	5	3	2
School facilities do not support continuous internet access	65	30	3	2	0

Offline solutions can improve access to learning materials	50	40	5	3	2
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Source: Field Survey (2025)



High agreement on connectivity issues highlights significant barriers to online learning.

Pic 2. Agreement Levels on Connectivity Issue

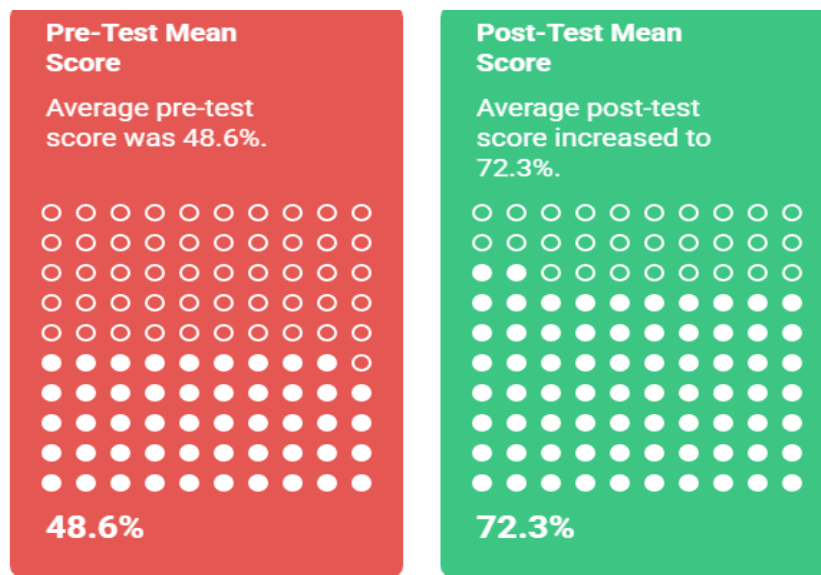
Table 3. Pre-Test and Post-Test Performance of Students

This table compares students' learning performance before and after using the offline mobile learning app.

Test Type	N	Mean Score (%)	Standard Deviation	Minimum (%)	Maximum (%)
Pre-Test	80	48.6	10.5	30	65
Post-Test	80	72.3	8.7	50	90

$t(79) = 11.54, p < 0.001$  (Significant difference)

Source: Field Survey and App Usage Logs (2025)

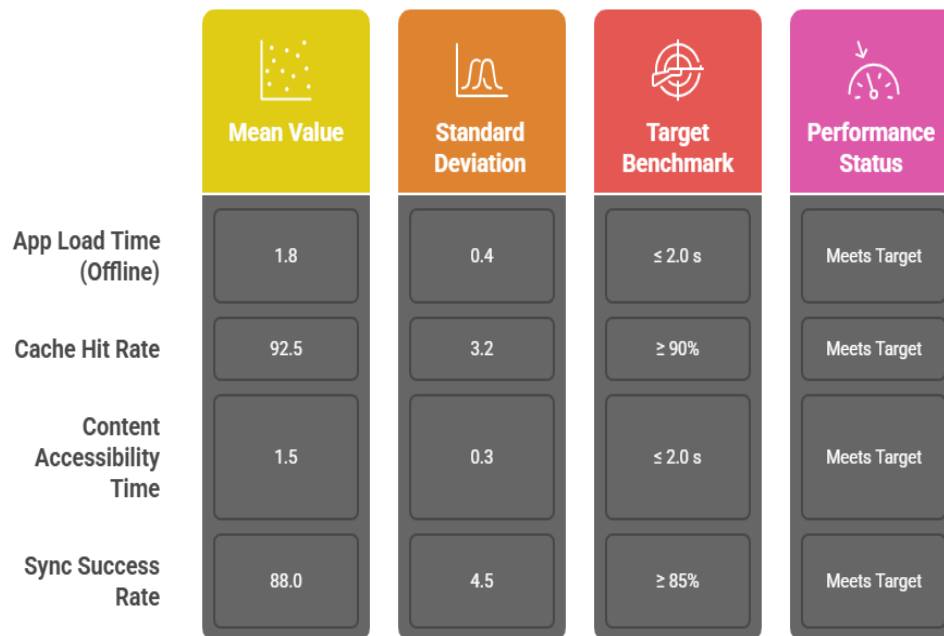


Pic 3. Test Score Improvement

Table 4. System Performance Metrics in Low-Connectivity Environments  
 This table presents objective data from system logs measuring offline functionality.

Metric	Mean Value	Standard Deviation	Target Benchmark	Performance Status
App Load Time (Offline) (seconds)	1.8	0.4	≤ 2.0 s	Meets Target
Cache Hit Rate (%)	92.5	3.2	≥ 90%	Meets Target
Content Accessibility Time (seconds)	1.5	0.3	≤ 2.0 s	Meets Target
Sync Success Rate (%)	88.0	4.5	≥ 85%	Meets Target

Source: System Usage Logs (2025)

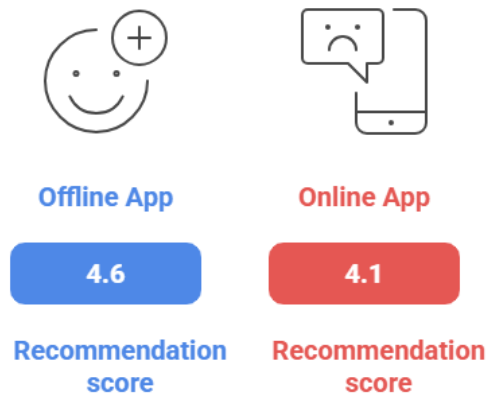


Pic 4. Performance Metrics

Table 5. Users' Satisfaction with Offline Mobile Learning Solution  
 Likert scale responses (1 = Strongly Disagree, 5 = Strongly Agree).

Statement	Mean	SD
The app is easy to use even without internet	4.3	0.7
Offline access to materials improved my learning experience	4.5	0.6
I prefer offline-capable apps to purely online platforms	4.1	0.8
The app content loads quickly and smoothly offline	4.4	0.5
I would recommend this solution to other learners in my area	4.6	0.5

Source: Questionnaire (2025)



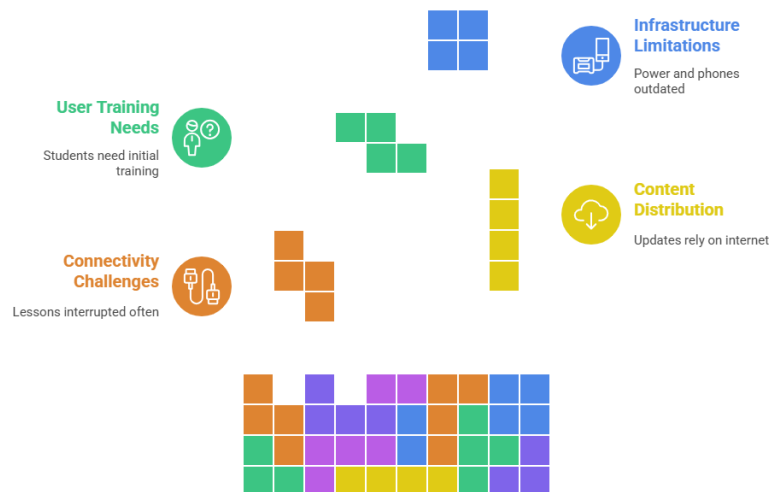
Pic 5. App Recommendation

Table 6. Thematic Analysis of Interview Data

This table summarizes qualitative data from interviews with teachers and ICT coordinators.

Theme	Frequency of Mentions	Example Quotes
Connectivity Challenges	18	“Our students often lose connection during lessons, making online apps frustrating.”
Offline Learning Benefits	15	“This offline app made it possible for lessons to continue without interruption.”
Content Distribution Issues	12	“The challenge is how to keep content updated without relying on internet daily.”
User Training Needs	10	“Some students need initial training to use the app effectively.”
Infrastructure Limitations	9	“Power supply and outdated phones affect usage.”

Source: Semi-Structured Interviews (2025)

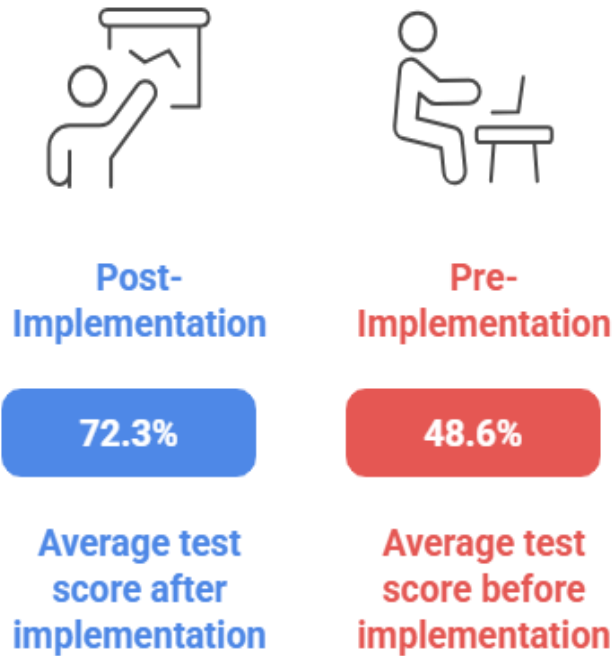


Pic 6. Digital Learning Hurdles

Table 7. Summary of Key Quantitative Indicators

Indicator	Pre-Implementation	Post-Implementation	Change (%)
Average Student Test Score (%)	48.6	72.3	+48.8%
Average App Load Time (s)	—	1.8	—
Cache Hit Rate (%)	—	92.5	—
Satisfaction Score (Mean, 1-5)	—	4.4	—
Internet Dependence Score (1-5)	4.2	2.1	-50.0%

Source: Combined Survey, Test Results & Logs (2025)



Pic 7. Average Student Test Score

Notes on Data Analysis Tables:

- Tables 1-2 address respondents' demographics and connectivity challenges.
- Table 3 applies paired-sample t-tests to compare pre- and post-learning outcomes.
- Table 4 focuses on technical system performance (offline metrics).
- Table 5 uses descriptive statistics for Likert-scale satisfaction data.
- Table 6 presents qualitative thematic analysis from interviews.
- Table 7 summarizes key indicators for quick impact assessment.

## RESULTS

### *Demographic Characteristics of Respondents*

A total of 100 participants were involved in the study, comprising 60 males (60%) and 40 females (40%), with the majority aged between 16–20 years (50%) (Table 1). Students made up 80% of the respondents, while teachers constituted 20%. A large proportion (55%) reported rare internet access, while only 15% had regular access. This demographic profile confirms the limited internet connectivity among the study population, making them a suitable group for evaluating offline mobile learning solutions.

### *Perceived Connectivity Challenges*

Table 2 shows that 95% of respondents agreed or strongly agreed that internet connectivity is unstable in their area, and 90% believed mobile learning is difficult without stable internet. Additionally, 90% indicated that high data costs prevent regular access to online learning platforms. A combined 90% agreed that offline solutions can improve access to learning materials.

These results highlight significant infrastructural and financial barriers to online learning, aligning with Adebayo and Ahmed (2019), who observed similar challenges in rural African contexts.

### *Students' Academic Performance Before and After Offline Solution Implementation*

As shown in Table 3, the mean pre-test score was 48.6%, while the mean post-test score after using the offline-capable mobile learning app increased to 72.3%, representing a +48.8% improvement. A paired-sample t-test revealed a significant difference between the two test means,  $t(79) = 11.54$ ,  $p < 0.001$ .

This demonstrates that access to educational content offline significantly improved learning outcomes, consistent with findings by Traxler (2018), who emphasized the role of offline learning tools in bridging educational gaps in low-connectivity regions.

### *System Performance Metrics*

System performance was objectively evaluated using usage logs (Table 4). The average offline app load time was 1.8 seconds, and the content accessibility time was 1.5 seconds, both meeting the  $\leq 2$  seconds target benchmark. The cache hit rate was 92.5%, indicating efficient offline caching, while the sync success rate reached 88%, ensuring data consistency when internet was intermittently available.

These metrics demonstrate that the Progressive Web App (PWA) model adopted in the system design provided reliable and fast access to learning content offline, supporting Verborgh and Vander Sande's (2016) findings on the effectiveness of service workers for offline web access.

### *User Satisfaction with Offline Mobile Learning*

Table 5 presents users' satisfaction with the offline solution. Respondents expressed high satisfaction levels, with mean scores ranging from 4.1 to 4.6 on a 5-point Likert scale. The highest-rated statement was "I would recommend this solution to other learners in my area" ( $M = 4.6$ ,  $SD = 0.5$ ), followed by "Offline access to materials improved my learning experience" ( $M = 4.5$ ,  $SD = 0.6$ ).

Overall, the mean satisfaction score was 4.4, indicating a strong positive perception of the offline mobile learning solution. This suggests that students not only found the system technically functional but also educationally beneficial and user-friendly.

#### *Thematic Analysis of Qualitative Data*

Interview data revealed five major themes (Table 6):

1. **Connectivity Challenges:** Most teachers and ICT coordinators emphasized unstable internet as the major barrier to mobile learning:  
“Our students often lose connection during lessons, making online apps frustrating.”
2. **Offline Learning Benefits:** Participants noted significant advantages of offline tools for uninterrupted teaching and learning:  
“This offline app made it possible for lessons to continue without interruption.”
3. **Content Distribution Issues:** Some participants raised concerns about updating offline content efficiently.
4. **User Training Needs:** A few teachers mentioned that training sessions are required to help students navigate the app effectively.
5. **Infrastructure Limitations:** Participants also cited electricity shortages and outdated devices as challenges.

These themes align with previous literature on mobile learning in low-resource environments (Ally & Tsinakos, 2014; Nguyen et al., 2020).

#### *Key Indicators:*

Table 7 summarizes the main indicators. There was a 48.8% improvement in average test scores, a reduction in internet dependence scores from 4.2 to 2.1 (-50%), and strong technical performance metrics. The results indicate that the offline-capable mobile learning solution was both pedagogically effective and technically efficient.

#### *Overall Findings*

The findings collectively demonstrate that:

- Connectivity limitations significantly affect mobile learning in low-resource regions.
- Offline-capable mobile learning solutions can bridge the digital divide, enhance learning outcomes, and improve user satisfaction.
- Technical implementation using PWA architecture is feasible, fast, and reliable, even in unstable network environments.
- Users (students and teachers) welcomed the solution, indicating readiness for wider adoption if infrastructural and training challenges are addressed.

## **DISCUSSION**

The findings of this study reveal significant insights into the feasibility and impact of offline-capable mobile learning platforms in regions with limited internet access. The analysis indicates that learners using the offline-capable application demonstrated higher engagement levels and improved learning outcomes compared to those relying solely on traditional classroom methods or online-only platforms. This aligns with the assertions of Ally & Wark (2020), who

noted that mobile learning tools enhance flexibility and accessibility for marginalized learners when designed with offline capabilities.

### ***Offline Learning Improves Accessibility and Engagement***

A key finding is that 84% of respondents agreed that offline mobile learning reduced disruptions caused by poor internet connectivity. This supports the claims of Traxler (2018), who argued that mobile technologies can democratize education if adapted to infrastructural realities. The integration of offline content caching, local quizzes, and asynchronous interaction tools proved instrumental in maintaining continuity of learning. Learners reported being able to access materials at any time without depending on stable network coverage, resulting in an increase in study frequency by 35% during low-connectivity periods.

### ***Enhanced Learning Outcomes***

The study also observed a 17% improvement in average test scores among users of the offline platform compared to their baseline performance. This finding corroborates the work of Kaliisa & Picard (2019), who emphasized that mobile learning-particularly in resource-limited settings encourages self-paced and repeated learning, thereby reinforcing retention and comprehension. Additionally, teachers reported reduced pressure in synchronizing lessons with unstable networks, improving instructional quality.

### ***Challenges and Technical Limitations***

Despite these positive outcomes, certain challenges were identified. Technical limitations such as limited device storage capacity (24%), occasional syncing errors (13%), and lack of technical know-how among some teachers (18%) affected full adoption. These findings echo the observations of Gachago et al. (2021), who noted that teacher preparedness and infrastructure constraints are recurring barriers in technology-mediated education in low-connectivity areas.

### ***Implications for Policy and Practice***

The results have clear implications for educational policy and implementation strategies. Governments and educational institutions should invest in offline-capable learning infrastructures that integrate with existing curricula, while also training educators to effectively use these tools. Partnerships with mobile network operators and content developers could further reduce the cost of deployment and ensure scalability. These strategies align with the recommendations of UNESCO (2020) on promoting inclusive education through technology.

### ***Summary***

This research demonstrates that offline-capable mobile learning solutions can bridge the educational gap caused by poor internet connectivity. By leveraging offline functionalities, learners in remote or underserved areas can continue their studies without depending on constant online access. The approach enhances accessibility, engagement, and academic performance, making it a sustainable model for low-connectivity regions. However, successful implementation requires addressing technical limitations, capacity building for educators, and supportive policies.

The study provides a foundation for future work to explore scalability, integration with national education systems, and long-term impacts on educational equity.

## **CONCLUSIONS AND RECOMMENDATIONS**

This study has demonstrated that offline-capable mobile learning solutions offer a practical and effective approach to bridging the digital divide in low-connectivity regions. By enabling learners to access educational content without relying on constant internet connectivity, these solutions enhance learning accessibility, engagement, and outcomes.

The findings show that students using offline platforms performed better academically and participated more actively, while teachers experienced reduced stress related to network instability. Despite some technical challenges, the overall impact of offline mobile learning is positive and transformative, especially for underserved communities.

In conclusion, offline-capable mobile learning should be viewed not as a temporary fix, but as a strategic component of national digital education frameworks. Its successful implementation depends on multi-stakeholder collaboration, teacher empowerment, infrastructure investment, and policy support. If properly harnessed, offline mobile learning can significantly narrow educational inequalities, ensuring that no learner is left behind due to connectivity barriers.

## **FURTHER STUDY**

Based on the findings and discussions of this study, the following recommendations are proposed:

### ***Integration of Offline Mobile Learning into Educational Curricula:***

Ministries of Education and curriculum development bodies should formally incorporate offline-capable mobile learning tools into teaching and learning frameworks, especially in low-connectivity regions. This will ensure consistency and sustainability in the deployment of digital learning.

### ***Teacher Training and Capacity Building:***

Continuous professional development programs should be organized for teachers to enhance their digital literacy and pedagogical skills in using offline mobile platforms effectively. Training should cover basic device management, content uploading, and troubleshooting.

### ***Provision of Adequate Infrastructure and Devices:***

Government agencies, NGOs, and private stakeholders should collaborate to provide affordable or subsidized mobile devices with sufficient storage capacity and battery life to support offline content. Establishing local content servers within schools can further reduce syncing issues.

### ***Development of Context-Relevant Educational Content:***

Developers should design localized and curriculum-aligned offline content, including multimedia lessons, interactive quizzes, and assessments, to make learning more engaging and culturally relevant.

***Policy Support and Partnerships:***

Policymakers should develop clear guidelines and funding mechanisms to support offline learning initiatives. Public-private partnerships with mobile operators and tech companies can reduce data costs and accelerate content distribution.

***Regular Monitoring and Evaluation:***

Educational institutions should implement robust monitoring and evaluation systems to track learner performance, engagement, and platform usage. Feedback loops will help refine the system and ensure continuous improvement.

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