GLOBAL ACADEMIC INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY (GAIJM)



Received: 22.01.2026
Accepted: .30.04.2026
Published: 06.05.2026

Vol.1.1.2026 pp.45-50 **http://globreshub.org/index.php/gaijm https://doi.org/10.65186/gaijm.v1.i6**

ARTIFICIAL INTELLIGENCE-DRIVEN OFFLINE E-LEARNING PLATFORM FOR UNIVERSITIES IN LOW-CONNECTIVITY REGIONS

OMOROGBE Osasu Harry (PhD) [1]
Department of Cybersecurity, Igbinedion University, Okada. Edo State, Nigeria
https://orcid.org/0000-0002-6864-3665, omorogbe.harry@iuokada.edu.ng
AMENAGHAWON Vincent Airuoyuwa (PhD) [2]
Computer Science and Information Technology. Igbinedion University Okada,
vincent.amen@iuokada.edu.ng

EDUJE,Anthony Ighoakpo[3]
Department of Computer Science and Information Technology, Igbinedion University, Okada. Edo State, Nigeria Email: dujeit@yahoo.com

OBANDE Obeka Bonnie[4]
Igbinedion University Medical Library, Okada, Edo State, bonnie.obande@iuokada.edu.ng

Abstract

The expansion of digital education has transformed teaching and learning processes across higher education institutions worldwide. However, universities in developing countries continue to face major obstacles in implementing effective e-learning systems due to poor internet connectivity, unstable electricity supply, inadequate digital infrastructure, and high bandwidth costs. Most modern Learning Management Systems (LMS) rely heavily on cloud computing and continuous internet access, making them difficult to sustain in low-resource environments. This study presents the design and implementation of an Artificial Intelligence-driven offline e-learning platform specifically developed for universities operating in low-connectivity regions. The system integrates lightweight artificial intelligence services, offline synchronization, adaptive content delivery, intelligent student monitoring, and automated assessment mechanisms into a locally deployable LMS environment. The platform was developed using Python, Moodle APIs, Tensor Flow Lite, Flask, and local edge servers. A pilot implementation involving undergraduate students at Igbinedion University demonstrated improvements in student participation, content accessibility, and instructional efficiency. The study found that offline AI-enabled learning environments can significantly improve educational accessibility and continuity in resource-constrained institutions. The findings further suggest that localized intelligent educational systems may serve as sustainable alternatives to fully cloud-dependent learning infrastructures in developing economies such as Nigeria. **Keywords:** Artificial Intelligence, Offline Learning, E-Learning Systems, Learning Management Systems, Educational Technology, Developing Economies, Nigeria, Adaptive Learning, Edge Computing

*Corresponding author. Omorogbe, O H. et al (2026) Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. See for details: https://creativecommons.org/licenses/by-nc-nd/4.0/

GAIJM Vol.1.1.2026 pp.45-50

http://globreshub.org/index.php/gaijm

1. Introduction

The increasing dependence on digital technologies in education has fundamentally changed the structure of teaching and learning across higher institutions worldwide. Universities now rely extensively on e-learning platforms for instructional delivery, communication, assessment, and academic management. Learning Management Systems have become central components of higher education because they provide virtual environments through which students and instructors can interact beyond physical classrooms.

The global shift toward online education accelerated significantly during and after the COVID-19 pandemic, compelling institutions to adopt digital learning infrastructures at unprecedented levels (Dhawan, 2020). While universities in technologically advanced countries adapted relatively quickly, institutions in developing regions encountered substantial challenges associated with infrastructure, affordability, and accessibility.

In Nigeria and many other African countries, internet connectivity remains inconsistent and expensive for a large percentage of university students. Many learners depend on unstable mobile data services and lack access to high-speed broadband internet. In addition, electricity instability, limited institutional ICT infrastructure, and insufficient technical support continue to hinder the effective implementation of digital learning systems (Aboagye, Yawson, & Appiah, 2021).

Most conventional e-learning systems such as Moodle and Canvas LMS were originally designed for environments with relatively stable internet access. These platforms depend heavily on continuous synchronization with cloud servers, frequent updates, and high-bandwidth multimedia delivery. Consequently, students in low-connectivity environments often experience slow access speeds, interrupted learning sessions, delayed submissions, and reduced participation.

Artificial Intelligence has emerged as one of the most transformative technologies in educational innovation. AI technologies can personalize learning experiences, automate grading, monitor learner progress, and support predictive intervention systems (Holmes, Bialik, & Fadel, 2022). Despite these advantages, most AI-enabled educational systems remain cloud-dependent and computationally expensive, limiting their applicability in resource-constrained environments.

This study addresses these challenges by proposing and implementing an Artificial Intelligence-driven offline e-learning platform designed specifically for universities operating under low-connectivity conditions. The proposed platform integrates lightweight AI services directly into a localized learning environment capable of functioning with minimal internet dependency. The study emphasizes accessibility, affordability, adaptability, and sustainability within the context of developing economies.

The objectives of the study are to:

1. Develop an offline-capable AI-driven e-learning platform for universities in low-connectivity regions.
2. Integrate intelligent learning support services into a localized LMS environment.
3. Evaluate the effectiveness of the system in improving accessibility, engagement, and instructional efficiency.
4. Assess the applicability of localized AI-enabled educational systems within Nigerian higher education institutions.

2. Literature Review

2.1 E-Learning in Resource-Constrained Environments

E-learning has become an essential component of higher education globally because it supports flexible learning, remote access to instructional materials, and digital collaboration. However, the success of e-learning implementation depends

heavily on infrastructure availability, internet accessibility, and institutional readiness.

Several studies have identified infrastructural barriers as major obstacles to effective e-learning adoption in developing countries. According to Adarkwah (2021), students in many African countries experience persistent difficulties associated with unstable internet access, insufficient digital devices, and inadequate institutional technological support. Similarly, Aboagye et al. (2021) found that high internet costs and network instability significantly affected student participation in online learning during the pandemic period.

In Nigeria, the digital divide between urban and rural regions further complicates access to online education. Students in underserved communities frequently encounter difficulties downloading instructional materials, streaming lectures, or participating in virtual learning activities.

These challenges have increased the demand for educational systems capable of functioning effectively under low-bandwidth and intermittent connectivity conditions.

2.2 Artificial Intelligence in Education

Artificial Intelligence has increasingly become a critical tool for improving teaching and learning processes. AI applications in education include adaptive learning systems, intelligent tutoring systems, automated assessment platforms, recommendation systems, and predictive learning analytics (Zhai et al., 2021).

AI-driven educational systems can analyze learner behavior and provide personalized instructional support based on individual learning needs. Intelligent tutoring systems can simulate human instructional interactions by offering immediate feedback and tailored learning pathways. Automated grading systems also help reduce instructor workload while improving feedback efficiency.

Holmes et al. (2022) observed that AI technologies improve learner engagement and academic performance by enabling personalized and data-driven learning experiences. Similarly, Luckin et al. (2016) argued that AI can transform education by supporting adaptive learning environments that respond dynamically to student needs.

Despite these benefits, most AI-enabled educational systems rely on cloud computing infrastructures that require stable internet connectivity and significant computational resources.

2.3 Offline and Localized Learning Systems

Offline learning systems are designed to support educational access in environments with limited or unstable internet connectivity. Such systems store educational resources locally and synchronize updates whenever connectivity becomes available.

Localized educational systems have become increasingly important in developing countries because they reduce dependence on external cloud infrastructures and minimize bandwidth consumption. Edge computing technologies further support localized learning by enabling data processing directly on local devices or institutional servers (Shi et al., 2016).

TensorFlow Lite and lightweight AI frameworks have enabled the deployment of intelligent services on low-power devices such as Raspberry Pi systems and smartphones (Warden & Situnayake, 2019). These technologies make localized AI-enabled educational systems more feasible for universities operating under infrastructural constraints.

3. System Design and Architecture

The proposed AI-driven offline e-learning platform was designed using a modular architecture consisting of interconnected components responsible for content delivery,

learner monitoring, adaptive support, and synchronization.

3.1 Local Learning Environment

The system operates primarily within a localized institutional network hosted on edge servers. Educational materials including lecture notes, videos, quizzes, and assignments are stored locally to ensure continuous accessibility even when internet connectivity is unavailable.

Students access the system through smartphones, tablets, and desktop computers connected either through campus intranet systems or localized wireless networks.

3.2 Intelligent Learning Support Module

The Intelligent Learning Support Module integrates lightweight AI services into the learning environment. The module performs several functions including:

- Monitoring student engagement
- Recommending supplementary learning materials
- Providing automated learning feedback
- Identifying academically at-risk students
- Supporting personalized learning pathways

The recommendation engine analyzes learner behavior such as course participation, quiz attempts, assignment completion, and content access frequency to suggest relevant instructional materials.

3.3 Automated Assessment System

The platform includes an automated assessment system capable of evaluating quizzes, assignments, and short-answer responses. The system also supports plagiarism detection and feedback generation.

Automated grading significantly reduces instructor workload while improving the speed of academic feedback delivery.

3.4 Offline Synchronization Mechanism

The synchronization module enables the platform to function effectively without continuous internet connectivity. Student activities, assessment results, and course updates are stored locally and synchronized with external servers whenever internet access becomes available.

This mechanism minimizes data consumption and ensures learning continuity during network interruptions.

3.5 Administrative Analytics Dashboard

The platform provides instructors and administrators with real-time analytics dashboards showing:

- Student participation trends
- Course completion statistics
- Assessment performance summaries
- Engagement indicators
- Intervention recommendations

These analytics support evidence-based instructional decision-making and early academic intervention.

4. Methodology

4.1 Research Design

The study adopted a system development and experimental evaluation approach. The research involved the design, implementation, deployment, and evaluation of the AI-driven offline e-learning platform within a university learning environment.

4.2 System Development Tools

The platform was developed using:

- Python 3.10
- Flask Framework
- Moodle 4.3 APIs
- TensorFlow Lite
- SQLite Database
- Raspberry Pi Edge Servers

The system was optimized for mobile access due to the high prevalence of smartphone-based internet usage among Nigerian university students.

4.3 Participants and Data Collection

The study involved 140 undergraduate students from the Computer Science Department at Igbinedion University over a thirteen-week semester.

Data collected during the study included:

- Student login records
- Course participation logs
- Assignment submissions
- Quiz results
- Discussion forum activities
- Content access statistics

Interviews and questionnaires were also administered to evaluate student and instructor experiences with the platform.

4.4 Evaluation Criteria

The system was evaluated based on:

- Accessibility under low-connectivity conditions
- Student engagement levels
- System usability
- Instructor workload reduction
- Learning continuity during internet disruptions
- Student satisfaction

5. Results and Discussion

The implementation results demonstrated that the proposed platform significantly improved educational accessibility and participation in low-connectivity environments.

Students reported improved access to instructional materials because the platform functioned effectively without requiring continuous internet connectivity. Offline accessibility reduced interruptions associated with unstable mobile networks and limited bandwidth availability.

The adaptive recommendation system increased learner engagement by directing students toward personalized learning resources based on their academic activities and performance patterns. Students who previously struggled with course participation demonstrated improved consistency in accessing learning materials.

The automated assessment module reduced instructor grading workload and improved feedback delivery speed. Instructors reported that automated analytics helped them identify students requiring academic intervention more efficiently.

The offline synchronization mechanism also proved highly effective in preserving learning continuity during internet outages. Student activities performed offline were successfully synchronized once connectivity became available.

The findings align with previous studies emphasizing the importance of localized and low-bandwidth educational technologies for developing countries (Adarkwah, 2021; Holmes et al., 2022).

6. Implications for Higher Education in Nigeria

The study has significant implications for Nigerian universities and other institutions operating in resource-constrained environments.

First, localized AI-enabled learning systems provide sustainable alternatives to expensive cloud-dependent educational infrastructures.

Second, offline-capable platforms can significantly improve educational inclusion for students in rural and underserved communities with poor internet access.

Third, institutions can reduce operational costs associated with bandwidth consumption and cloud hosting services.

Finally, the study demonstrates that intelligent educational technologies can be adapted successfully to local infrastructural realities rather than relying exclusively on foreign cloud-based systems.

7. Conclusion

This study presented the development and implementation of an Artificial Intelligence-driven offline e-learning platform for universities operating in low-connectivity environments. The platform integrated lightweight AI services, localized content delivery, automated assessment, learner analytics, and offline synchronization mechanisms into a sustainable educational framework.

The findings demonstrated that offline AI-enabled learning systems can significantly improve accessibility, instructional efficiency, and learner engagement in resource-constrained higher education environments.

The study contributes to ongoing discussions on digital inclusion and sustainable educational technology adoption in developing economies such as Nigeria. It further establishes that localized intelligent educational systems can serve as practical and scalable alternatives to cloud-dependent learning infrastructures.

Future research may explore multilingual intelligent tutoring systems, solar-powered edge learning infrastructures, AI-supported vocational learning environments, and community-based offline educational networks.

References

Aboagye, E., Yawson, J. A., & Appiah, K. N. (2021). COVID-19 and e-learning: The challenges of students in tertiary institutions. *Social Education Research, 2*(1), 1–8.

Adarkwah, M. A. (2021). "I'm not against online teaching, but what about us?" ICT in Ghana post COVID-19. *Education and Information Technologies, 26*(2), 1665–1685.

Aljawarneh, S. A. (2020). Reviewing and exploring innovative ubiquitous learning tools in higher education. *Journal of Computing in Higher Education, 32*(1), 57–73.

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems, 49*(1), 5–22.

Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson Education.

Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: Vision and challenges. *IEEE Internet of Things Journal, 3*(5), 637–646.

Turnbull, D., Chugh, R., & Luck,J. (2021). Learning management systems: A review of the research methodology literature in Australia and China. *International Journal of Research & Method in Education, 44*(2), 164–178.

Warden, P., & Situnayake, D. (2019). *TinyML: Machine learning with TensorFlow Lite on Arduino and ultra-low-power microcontrollers*. O'Reilly Media.

Zhai, X., Yin, Y., Bower, M., & Chai, C. S. (2021). Artificial intelligence in education: A systematic literature review. *Educational Technology & Society, 24*(1), 1–17.