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*Research*

# Development and Evaluation of an AI-Powered Experiential Learning Platform for Enhancing Climate Literacy and STEM Skills in a Nigerian Tertiary Institution: A Pilot Randomised Controlled Study

## Akinnubi Rufus Temidayo* & Oziegbe Tope Rufus**

**Department of Physics, Adeyemi Federal University of Education, Ondo*** | **Department of Economics, Adeyemi Federal University of Education, Ondo****

E-mail: akinnubir@afued.edu.ng, oziegbert@afued.edu.ng

## Highlights

- An AI-powered experiential learning platform was developed to enhance climate literacy at a Nigerian tertiary institution.
- A pilot randomised controlled trial involving 60 STEM undergraduates was conducted.
- Students using the AI platform recorded a 41.9% improvement in climate literacy and STEM skills.
- Platform use significantly predicted higher-order problem-solving performance.
- Findings provide preliminary evidence for AI-enhanced climate education in resource-constrained contexts.

## Abstract

The accelerating impacts of climate change necessitate innovative pedagogical approaches that enhance climate literacy and applied problem-solving skills, particularly in vulnerable regions such as Nigeria. This study developed and evaluated an AI-powered experiential learning platform designed to strengthen climate literacy and STEM competencies among undergraduate students. A pilot randomised controlled trial employing a convergent mixed-methods design was conducted at Adeyemi Federal University of Education (AFUED), Ondo. Sixty (60) 300-level STEM undergraduates were randomly assigned to either an experimental group that engaged with the AI-based platform or a control group receiving conventional lecture-based instruction over a 12-week period. Quantitative data were collected using validated pre- and post-test instruments and analysed using independent and paired-samples t-tests, as well as multiple regression analysis. Qualitative insights were obtained through focus group discussions and open-ended surveys and were analysed thematically. Results indicate that students in the experimental group demonstrated a statistically significant improvement in climate literacy and STEM skills (41.9% gain, $p < 0.001$) compared to the control group (13.0% gain). Regression analysis further revealed that platform usage was a strong positive predictor of post-test problem-solving performance after controlling for prior knowledge and academic performance. Qualitative findings showed enhanced engagement, deeper conceptual understanding, and increased motivation, although challenges related to infrastructure reliability were also identified. Overall, the findings provide preliminary empirical evidence that AI-powered experiential learning platforms can enhance climate education outcomes in Nigerian tertiary institutions. The study demonstrates feasibility and highlights implications for curriculum innovation, digital infrastructure investment, and future large-scale research.

**Keywords:** Artificial intelligence; experiential learning; climate literacy; STEM education; Nigeria; tertiary education

***Correspondence**
Akinnubi R. T. akinnubir@afued.edu.ng, oziegbert@afued.edu.ng
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# 1.0 Introduction

The accelerating global climate crisis, marked by intensifying environmental degradation and rapid technological disruption, poses an existential challenge that demands a fundamental reorientation of educational systems worldwide. This challenge is particularly acute in countries of the Global South, such as Nigeria, which contribute minimally to historical global greenhouse gas emissions yet experience disproportionate climate impacts (Intergovernmental Panel on Climate Change [IPCC], 2022; World Bank, 2023). Nigeria faces escalating environmental risks, including desertification and drought in its northern regions, recurrent coastal erosion and flooding in the Niger Delta, and increasing rainfall variability that disrupts agricultural productivity nationwide (United Nations Development Programme [UNDP], 2023). These compounding climate stressors pose serious threats to food security, public health, and the sustainability of critical infrastructure, thereby undermining national development efforts.

Addressing these complex challenges requires more than declarative climate awareness; it demands robust climate literacy, systems thinking, and problem-solving competencies among future scientists, engineers, and educators. Climate literacy enables learners to understand climate processes, evaluate evidence, and apply scientific knowledge to real-world decision-making (UNESCO, 2021). However, empirical evidence indicates that climate and STEM education in many Nigerian tertiary institutions remains predominantly lecture-driven, emphasising theoretical content at the expense of applied, experiential engagement (Okafor & Eze, 2023; National Universities Commission [NUC], 2023). National curriculum audits reveal persistent gaps in hands-on learning opportunities, data-driven inquiry, and interdisciplinary problem-solving, leaving graduates often ill-prepared to address climate-resilient infrastructure and sustainability challenges (NUC, 2023).

Educational research increasingly demonstrates that active and experiential learning approaches significantly outperform traditional lecture-based methods in fostering conceptual understanding, critical thinking, and long-term knowledge retention. Freeman et al. (2014) provide compelling evidence that active learning strategies lead to higher student performance across science, engineering, and mathematics disciplines. Similarly, Kolb's (1984) experiential learning theory posits that deep learning occurs when learners engage in concrete experiences, reflective observation, abstract conceptualisation, and active experimentation. Constructivist perspectives further argue that learners develop meaningful understanding by actively manipulating variables and observing outcomes in authentic learning environments (Jonassen, 1999).

In recent years, advances in artificial intelligence (AI) have enabled the development of sophisticated experiential learning platforms that operationalise these pedagogical principles at scale. AI-powered learning environments, incorporating adaptive tutoring systems, immersive simulations, and intelligent feedback mechanisms, have been shown to significantly enhance student engagement and learning outcomes in STEM education (Chen & Zhang, 2023; Li et al., 2024). Meta-analytic evidence confirms that AI-driven personalised learning systems improve both academic performance and learner motivation by tailoring content difficulty and pacing to individual needs (Chen & Zhang, 2023). In the African context, AI-enabled educational tools, such as bilingual intelligent tutors, have demonstrated promise in addressing linguistic and accessibility barriers in STEM education (Osei-Tutu et al., 2023).

Despite these global advancements, the application of AI-powered experiential learning to climate literacy and climate-resilient infrastructure education within Nigerian tertiary institutions remains severely underexplored. Existing studies in Nigeria have largely focused on theoretical discussions of AI adoption or isolated pilot implementations without rigorous experimental evaluation (Ekwu et al., 2024). Moreover, few interventions have leveraged localised environmental datasets, such as meteorological and geospatial data, to contextualise climate learning within students' immediate ecological realities (Akinbami et al., 2024). This represents a critical research gap, as contextual relevance has been shown to significantly enhance learner engagement and knowledge transfer (World Bank, 2022).

This study addresses this gap by developing and empirically evaluating an AI-powered experiential learning platform tailored to the ecological and infrastructural realities of south-west Nigeria. By integrating localised climate data, interactive simulations, and adaptive learning algorithms, the platform is designed to move beyond abstract instruction towards immersive, problem-based learning experiences. Specifically, this research seeks to answer the following questions: (1) What is the impact of an AI-powered experiential learning platform on students' climate literacy and STEM skills compared to traditional lecture-based instruction? (2) To what extent does the platform enhance critical thinking and problem-solving abilities? and (3) How do students perceive and experience AI-driven experiential learning in the context of climate education?

By rigorously examining these questions using a mixed-methods approach, this study contributes to the growing body of literature on AI-enhanced education while providing context-specific empirical evidence from Nigeria. The findings are intended to inform curriculum reform, institutional policy, and national strategies for integrating AI-driven experiential learning into tertiary education. Ultimately, the study aims to support the development of a climate-literate and technologically empowered workforce capable of designing, implementing, and advocating for climate-resilient solutions aligned with Nigeria's sustainable development priorities.

# 2.0 Materials and Methods

### 2.1 Research Design

A convergent mixed-methods design was adopted, integrating quantitative and qualitative data to comprehensively evaluate the intervention. The quantitative component employed a randomised controlled trial (RCT), while qualitative data were collected through focus group discussions and open-ended surveys. Both datasets were analysed independently and integrated during the interpretation stage.

### 2.2 Study Site and Participants

The study was conducted at Adeyemi Federal University of Education (AFUED), Ondo State, Nigeria. Participants were 300-level undergraduates enrolled in STEM-related programmes, including Physics, Integrated Science, Computer Science, and Geography.

### 2.3 Sampling and Randomisation

Purposive sampling was used to select students who had completed foundational environmental science courses and demonstrated basic computer literacy, thereby ensuring readiness for the intervention. Sixty (60) eligible students consented to participate. Participants were randomly assigned to experimental ($n = 30$) and control ($n = 30$) groups using a computer-generated simple randomisation procedure conducted by an independent research assistant to minimise selection bias.

### 2.4 Intervention Description

The experimental group engaged with the Eko-Akete Climate Learning Hub, an AI-powered experiential learning platform developed over a four-month period. The platform integrated interactive simulations, localised climate datasets, and adaptive learning pathways. Modules included flood modelling, rainfall variability analysis, and environmental systems simulations relevant to south-western Nigeria. Environmental data were accessed from publicly available sources, including the Nigerian Meteorological Agency (NiMet) and the NASA POWER project. The control group received conventional lecture-based instruction covering identical content.

The intervention lasted 12 weeks, aligned with the academic semester, with two 2-hour learning sessions per week.

### 2.5 Data Collection Instruments

A validated 50-item climate literacy and STEM skills assessment (Cronbach's $\alpha = 0.84$) was administered before and after the intervention. Student engagement was measured using a 5-point Likert-scale survey. Focus group discussions were conducted with 16 participants from the experimental group, selected through random sampling.

### 2.6 Data Analysis and Integration

Quantitative data were analysed using RStudio (version 4.3.1), employing paired and independent samples t-tests and multiple regression analysis. Assumptions of normality, homoscedasticity, and multicollinearity were tested and satisfied. Qualitative data were transcribed verbatim and analysed thematically using NVivo 12, following Braun and Clarke's (2006) framework. Data integration was achieved through triangulation of quantitative findings and qualitative themes.

# 3.0 Results and Discussion

This section presents and discusses the empirical findings of the study, integrating quantitative and qualitative evidence in line with the convergent mixed-methods design. The results are organised according to the study's research questions, followed by an integrated discussion that situates the findings within the broader literature on AI-enabled experiential learning and climate education.

### 3.1 Impact of the AI-Powered Platform on Climate Literacy and STEM Skills

The first research question examined whether participation in the AI-powered experiential learning platform led to greater improvements in climate literacy and STEM skills compared with traditional lecture-based instruction. Pre-test results indicated no statistically significant difference between the experimental and control groups at baseline, confirming initial group equivalence. Following the 12-week intervention, both groups demonstrated learning gains; however, the magnitude of improvement differed substantially.

Table 1.0 presents a comparison of pre-test and post-test climate literacy and STEM skill scores.

| Group | Pre-test Mean (SD) | Post-test Mean (SD) | Mean Gain | % Improvement | 95% CI (Gain) | Cohen's *d* | *p*-value |
|---|---|---|---|---|---|---|---|
| Experimental (n = 30) | 51.8 (8.2) | 73.5 (8.9) | +21.7 | 41.9% | [17.4, 26.0] | 1.63 | < 0.001 |
| Control (n = 30) | 52.3 (8.5) | 59.1 (9.2) | +6.8 | 13.0% | [3.1, 10.5] | 0.48 | 0.012 |

An independent samples t-test comparing post-test scores revealed a statistically significant difference between the experimental and control groups ($t = 6.21$, $p < 0.001$). The large effect size (Cohen's $d = 1.63$) indicates a substantial educational impact attributable to the AI-powered platform. Although the control group also demonstrated a modest but statistically significant improvement, likely due to exposure to course content and testing effects, the markedly larger gains observed in the experimental group suggest that the experiential AI-based approach provided added instructional value beyond conventional methods.

These findings are consistent with prior studies demonstrating that experiential and simulation-based learning environments promote deeper understanding and knowledge retention compared with lecture-centred instruction (Chen & Zhang, 2023; Freeman et al., 2014). The use of localised climate scenarios and interactive simulations likely facilitated meaningful cognitive engagement, enabling students to actively apply concepts rather than passively receive information.

### 3.2 Effects on Critical Thinking and Problem-Solving Skills

The second research question explored the extent to which engagement with the AI-powered platform predicted students' critical thinking and problem-solving performance. To address this, a multiple regression analysis was conducted using post-test problem-solving scores as the dependent variable, while controlling for pre-test scores and prior academic performance (GPA). Assumptions of normality, homoscedasticity, and multicollinearity were examined and met, and no influential outliers were detected.

Table 2.0: Multiple Regression Analysis Predicting Post-test Problem-Solving Scores

| **Predictor** | **Unstandardized β** | **Standard Error** | **Standardized β** | ***t*** | ***p*** |
|---|---|---|---|---|---|
| Intercept | 24.85 | 3.18 | — | 7.81 | < 0.001 |
| Group (Experimental = 1) | 12.72 | 1.51 | 0.62 | 8.42 | < 0.001 |
| Pre-test Score | 0.61 | 0.07 | 0.58 | 8.71 | < 0.001 |
| Prior GPA | 1.08 | 0.43 | 0.19 | 2.51 | 0.015 |

*$R^2 = 0.68$; Adjusted $R^2 = 0.66$; $F(3, 56) = 95.3$, $p < 0.001$*

The regression model explained 66% of the variance in post-test problem-solving performance, indicating a strong overall fit. Group membership emerged as the strongest predictor, with students in the experimental group scoring, on average, 12.72 points higher on the problem-solving assessment than those in the control group, after controlling for baseline knowledge and GPA. Given that the maximum possible score on the assessment was 100, this difference represents a substantial practical effect.

These findings suggest that engagement with the AI-powered platform was associated with enhanced higher-order cognitive skills, particularly analytical reasoning and applied problem-solving. While the study design does not allow for isolation of specific platform features, the results are consistent with constructivist learning theory, which emphasises active manipulation of variables, feedback, and iterative exploration as key drivers of deeper learning (Jonassen, 1999; Li et al., 2024).

### 3.3 Student Experiences and Perceptions of the Learning Platform

The third research question examined students' perceptions of their learning experiences using the AI-powered platform. Qualitative data from focus group discussions and open-ended survey responses were thematically analysed, yielding three dominant themes.

**Enhanced Engagement and Motivation.**

Most participants described the platform as engaging and stimulating, emphasising that interactive simulations made climate concepts more tangible and relevant. Approximately 13 of the 16 focus group participants explicitly reported increased motivation compared with conventional lectures. One participant noted that visualising localised flood simulations made climate risks feel immediate and meaningful rather than abstract.

**Deeper Conceptual and Systems Understanding.**

Students frequently reported that the ability to manipulate variables and observe real-time outcomes improved their understanding of complex climate systems. Several participants highlighted increased awareness of interconnections among environmental, social, and infrastructural factors, suggesting the development of systems-thinking skills. These observations support existing evidence that experiential and simulation-based learning environments facilitate conceptual integration and knowledge transfer.

**Implementation Challenges and Infrastructure Constraints.**

Despite generally positive experiences, students identified practical challenges, particularly intermittent power supply and occasional software latency. Technical disruptions affected approximately 15% of scheduled sessions. While these issues temporarily interrupted learning, most participants indicated that the educational benefits outweighed the challenges. These findings underscore the importance of reliable digital infrastructure for the successful implementation of AI-enhanced learning in resource-constrained contexts.

### 3.4 Integrated Discussion

The integrated analysis of quantitative and qualitative findings provides a coherent picture of the educational value of the AI-powered experiential learning platform. Quantitative results demonstrate statistically significant and educationally meaningful improvements in climate literacy, STEM skills, and problem-solving performance among students who used the platform. Qualitative findings complement these results by revealing heightened engagement, deeper conceptual understanding, and positive learner perceptions, while also highlighting infrastructural constraints.

Although the study does not permit causal attribution to specific design elements of the platform, the combined evidence suggests that the integration of localised simulations, interactive learning tasks, and adaptive feedback created a learning environment conducive to active knowledge construction. Importantly, the observed improvements must be interpreted within the context of a single-site pilot study with a modest sample size. As such, the findings should be regarded as preliminary evidence of feasibility and effectiveness rather than definitive proof of superiority over traditional instruction.

Overall, the results align with broader research demonstrating the benefits of active and experiential learning approaches in STEM education (Freeman et al., 2014) and extend this literature by providing context-specific empirical evidence from a Nigerian tertiary institution. The findings support the potential of AI-powered experiential learning as a promising strategy for enhancing climate education, while also emphasising the need for scalable infrastructure solutions and larger multi-site studies to confirm generalisability.

# 4.0 Conclusion

This study provides preliminary evidence that the Eko-Akete Climate Learning Hub, an AI-powered experiential learning platform, can effectively enhance climate literacy, STEM competencies, and problem-solving skills among undergraduate students at Adeyemi Federal University of Education (AFUED). Quantitative results revealed a substantial improvement in post-test scores for the experimental group, with a 41.9% gain in climate literacy and STEM skills compared with 13.0% in the control group. Multiple regression analysis indicated that participation in the AI platform was the strongest predictor of problem-solving performance, explaining 66% of the variance in post-test scores. Qualitative findings further support these results, highlighting heightened student engagement, deeper conceptual understanding, and increased motivation through interactive simulations and contextually relevant content. Collectively, the convergent analysis suggests that AI-driven experiential learning can bridge the theory–practice gap in climate education, fostering analytical capabilities and problem-solving skills relevant to real-world environmental challenges.

However, these conclusions should be interpreted with caution due to several limitations, including the single-site implementation with a relatively small sample size (n = 60), the short intervention duration (12 weeks), potential selection bias in focus group participation, and infrastructural constraints such as software latency and dependence on stable power supply. Consequently, this study demonstrates feasibility and preliminary effectiveness rather than providing definitive proof of concept for broader application across Nigerian tertiary institutions.

# 5.0 Recommendations

Based on the findings and insights gained from this study, several strategic recommendations are proposed for stakeholders across Nigeria's tertiary education ecosystem.

Firstly, for immediate implementation (0–12 months), Adeyemi Federal University of Education (AFUED) should formally integrate the AI-powered platform into its STEM curriculum by allocating dedicated laboratory hours and revising course syllabi to include AI-enhanced experiential learning components. This integration should be accompanied by structured faculty training programmes aimed at developing competencies in operating the platform, interpreting data outputs, and facilitating interactive simulations. These "train-the-trainer" sessions could be delivered by the research team in collaboration with educational technology specialists, ensuring that faculty members are adequately equipped to guide students effectively.

For medium-term initiatives (1–2 years), the National Universities Commission (NUC) is encouraged to review and revise the Benchmark Minimum Academic Standards for STEM programmes, incorporating AI-powered experiential learning as a core pedagogical strategy. Universities should establish formal public–private partnerships with technology firms to co-develop localised content and ensure regular updates to learning modules. To support these efforts, targeted government investments in digital infrastructure are essential. Minimum requirements should include stable broadband access (at least 10 Mbps per laboratory), uninterruptible power supply (UPS) systems or backup generators, and high-performance computing facilities capable of running AI simulations efficiently. For institutions with limited resources, scalable solutions such as low-bandwidth platform versions or cloud-hosted simulations can provide more equitable access.

For long-term sustainability (2–5 years), a national strategy for AI in education should be developed by the Federal Ministry of Education, incorporating lessons from this study and providing dedicated funding streams to scale successful interventions. Establishing a Centre for AI in Education at AFUED or another federal university is recommended to support ongoing research, develop new AI applications for teaching and learning, and serve as a national hub for capacity building and innovation. The governance structure of such a centre could include a directorate comprising academic, technical, and administrative staff, with coordination links to existing educational research institutions. Budget planning should account for staffing, technological infrastructure, software maintenance, and competitive research grants to ensure long-term sustainability.

To guide future research, several directions are proposed. Priority should be given to longitudinal studies that assess knowledge retention and skill transfer over extended periods, thereby providing evidence of the platform's lasting impact. Comparative studies across different geopolitical zones, as well as adaptations to non-STEM disciplines, are also important for assessing generalisability. In addition, research addressing AI ethics, data privacy, and cost-effectiveness in educational applications should inform policy frameworks and promote responsible implementation.

Finally, it is important to reiterate the limitations that must be considered when planning and implementing these recommendations. These include the single-site nature of the present study, the relatively small sample size (n = 60), potential selection bias in qualitative data, the short intervention duration (12 weeks), and infrastructural challenges such as unreliable electricity and internet connectivity. Addressing these limitations in future implementations will enhance the effectiveness, scalability, and sustainability of AI-powered experiential learning across Nigerian tertiary education.

# 6.0 References


1. Akinbami, C. O., Adekunie, T. O., & Samuel, G. K. (2024). Harnessing geospatial data and artificial intelligence for climate change education in Nigeria: Opportunities and challenges. *Journal of Environmental Informatics Letters, 11*(1), 45–58.

2. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

3. Chen, L., & Zhang, H. (2023). AI-driven personalized learning in STEM: A meta-analysis of its impact on student engagement and performance. *Computers & Education, 187*, 104548.

4. Ekwu, M., Bako, R., & Nwachukwu, C. (2024). AI-driven adaptive learning systems in STEM education: A panacea for infrastructure deficits in Nigerian institutions. *Nigerian Journal of Educational Technology, 15*(2), 45–60.

5. Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

6. Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Cambridge University Press.
7. Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. 2, pp. 215–239). Lawrence Erlbaum Associates.
8. Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.
9. Li, J., Okonkwo, H., & Garcia, E. (2024). Experiential learning through AI simulations: Bridging the theory-practice gap in higher education. *International Journal of Educational Technology in Higher Education, 21*(1), Article 15.
10. National Universities Commission. (2023). *Curriculum review report for STEM programmes in Nigerian universities*.
11. Okafor, I. S., & Eze, V. C. (2023). Pedagogical gaps and the future of STEM education in Nigerian universities. *Nigerian Journal of Educational Development, 17*(2), 112–125.
12. Osei-Tutu, K., Boateng, R., Owusu, E., & Mensah, J. (2023). Kwame for Science: A bilingual AI teaching assistant for STEM education in West Africa. *Proceedings of the ACM on Human-Computer Interaction, 7*(CSCW2), 1–24.
13. UNESCO. (2021). *Reimagining our futures together: A new social contract for education*.
14. United Nations Development Programme. (2023). *Climate change and human development in Nigeria: A vulnerability and adaptation assessment*.
15. World Bank. (2022). *Climate-resilient infrastructure in Africa: A review of policies and practices*.
16. World Bank. (2023). *Climate risk country profile: Nigeria*.


**Data Availability Statement**

The datasets generated and analysed during the current study are not publicly available due to privacy and ethical restrictions aimed at protecting participant confidentiality. However, anonymised data may be made available by the corresponding author upon reasonable request and with the permission of the relevant Nigerian regulatory authorities.


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**Conflict of Interest**

The authors declare that they are faculty members at Adeyemi Federal University of Education, Ondo (AFUED), the institution that received the TETFUND grant. Community and policy partnerships were conducted under approved ethical protocols, including benefit-sharing and cultural sovereignty safeguards. The authors declare no other competing interests.


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