Effect of Artificial Intelligence (AI)-Powered Personalized Learning on Students' Achievement and Retention at Secondary-School Level Ecology in Ugba Town

Aondoaseer Kundushima Daniel
Center for Undergraduate Studies,
College of Education, Katsina-Ala,
in affiliation with the University of Calabar
Email: aondoaseerkundushima@gmail.com

Laagye, Z. T.
Department of Biology,
College of Education, Katsina-Ala
Email: laagyezachariah@gmail.com

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Abstract
Ecology is an important component of secondary school biology because it provides learners with knowledge for understanding organisms, ecosystems, environmental interactions, and sustainability. However, ecology can involve complex and interrelated concepts that require learners to integrate multiple relationships and processes. This study investigated the effect of artificial intelligence (AI)-powered personalized learning on students' achievement and retention at secondary school-level ecology in Ugba Town, Logo Local Government Area of Benue State, Nigeria. The study adopted a non-randomized pretest-posttest control-group quasi-experimental design. The population comprised SS II Biology students in the selected secondary schools, while a sample of 40 students from two intact classes was used, with 20 students assigned to the AI-powered personalized learning group and 20 to the conventional-method group. Data were collected using the Ecology Achievement Test (EAT) and Ecology Retention Test (ERT). Mean and standard deviation were used to answer the research questions, while independent-samples t tests were used to test the null hypotheses at the 0.05 significance level. The achievement result showed no statistically significant difference between the AI-powered personalized learning group (M = 13.85, SD = 3.93) and the conventional group (M = 12.25, SD = 3.30), t(38) = 1.39, p = *0*.175, 95% CI [−0.75, 3.95]. In contrast, the retention result showed a statistically significant difference, with the AI group (M = 16.45, SD = 2.58) outperforming the conventional group (M = 11.55, SD = 3.47), t(38) = 5.06, p *=0.000, 95% CI [2.94, 6.86]. The study concludes that AI-powered personalized learning may be particularly valuable for strengthening the retention of difficult ecological concepts, although the evidence from this study does not demonstrate a statistically significant advantage for immediate achievement.*

Keywords: *artificial intelligence; personalized learning; ecology; academic achievement; retention; secondary school biology*

Introduction

Ecology is a major component of biology concerned with relationships among organisms and between organisms and their physical environment. At the secondary school level, ecological learning requires students to understand interconnected processes such as population relationships, energy flow, nutrient cycling, environmental change, and ecosystem dynamics. Evidence from Nigerian secondary-school research indicates that instructional approaches can influence students' performance and retention in ecology. For example, Mahmud et al. (2022) reported that a field-trip approach produced better academic performance and retention in ecology than lecture-based instruction, highlighting the importance of instructional design in ecological learning. Retention is particularly important in biology because meaningful learning requires students to preserve and apply concepts beyond the immediate teaching episode. Onowugbeda et al. (2024) found that a culturally, technologically, and contextually oriented pedagogy significantly improved retention of biology concepts among Nigerian senior secondary students. Such findings support the broader view that instructional environments that actively engage learners and connect content with meaningful contexts can contribute to more durable learning. Recent developments in artificial intelligence (AI) have created new possibilities for individualized instruction. AI in education encompasses systems that can analyse learner information, provide feedback, recommend learning resources, and adapt instructional experiences to learners' needs. Tapalova and Zhiyenbayeva (2022) describe AI-supported personalized learning as involving technologies such as intelligent agents, machine learning, chatbots, expert systems, and personalized educational environments. These technologies can potentially make learning pathways more responsive to differences among learners.

Systematic reviews indicate that AI applications in education are expanding rapidly, with research examining intelligent tutoring, adaptive learning, learning analytics, assessment, feedback, and personalized learning. Wang et al. (2024) found that AI in education has developed into a broad research field involving multiple applications, research designs, and educational contexts. Similarly, Mustafa et al. (2024) identified substantial growth in AI-in-education research while emphasizing the need for stronger evidence regarding pedagogical effectiveness, context, and implementation. In science education specifically, Almasri (2024) reported that AI is being applied to teaching, learning, assessment, and other dimensions of science education, while also noting that outcomes depend on how AI is integrated into instruction. AI-powered personalized learning is particularly relevant to secondary education because students differ in prior knowledge, learning pace, and support needs. Farhood et al. (2025), in a systematic review of 125 studies, found that AI-based personalized learning is being applied across K–12 and higher education through content recommendation, tutoring and support, and feedback and assessment. Yim and Su (2025) similarly reviewed AI learning tools in K–12 education and identified a range of learner outcomes and pedagogical approaches. These findings suggest that AI can provide mechanisms for individualized learning, but they do not imply that AI automatically produces better achievement in every educational setting.

Despite the growing international literature, empirical evidence concerning AI-powered personalized learning in Nigerian secondary-school biology remains limited, particularly for ecology. Existing Nigerian studies have demonstrated that innovative, contextual, and technology-supported approaches can improve biology retention, while ecology-specific research has also shown advantages for alternative instructional approaches over conventional lecture methods (Mahmud et al., 2022; Onowugbeda et al., 2024). However, the specific effect of AI-powered personalized learning on achievement and retention in ecology at the secondary-school

level in Ugba Town has not been established. This study therefore addresses this gap by comparing AI-powered personalized learning with the conventional teaching method.

Objectives of the Study

The main objective of the study was to investigate the effect of AI-powered personalized learning on students' achievement and retention at secondary-school level ecology in Ugba Town, Logo Local Government Area, Benue State, Nigeria.

Specifically, the study sought to:

1. Determine the mean achievement score of students taught ecology using the conventional teaching method;
2. Determine the mean achievement score of students taught ecology using AI-powered personalized learning;
3. Determine the mean retention score of students taught ecology using the conventional teaching method; and
4. Determine the mean retention score of students taught ecology using AI-powered personalized learning.

Research Questions

The following research questions guided the study

1. What is the mean achievement score of students taught ecology using the conventional teaching method?
2. What is the mean achievement score of students taught ecology using AI-powered personalized learning?
3. What is the mean retention score of students taught ecology using the conventional teaching method?
4. What is the mean retention score of students taught ecology using AI-powered personalized learning?

Research Hypotheses

The following null hypotheses were tested at the .05 level of significance:

$H0_1$: There is no statistically significant difference in the mean achievement scores of students taught ecology using AI-powered personalized learning and those taught using the conventional teaching method.

$H0_2$: There is no statistically significant difference in the mean retention scores of students taught ecology using AI-powered personalized learning and those taught using the conventional teaching method.

Research Methodology

Research Design

The study adopted a non-randomized pretest–posttest control-group quasi-experimental design. This design was considered appropriate because intact classes were used and the study compared students exposed to two different instructional conditions.

Area of the Study

The study was conducted in selected secondary schools in Ugba Town, Logo Local Government

Area, Benue State, Nigeria.

Population of the Study

The population comprised SS II Biology students in the selected secondary schools in Ugba Town during the 2025/2026 academic session.

Sample and Sampling Technique

A sample of 40 students from two intact classes was used. Twenty students constituted the AI-powered personalized learning group, while 20 constituted the conventional-method group. The classes were assigned to the two instructional conditions for the experiment.

Instrument for Data Collection

The instruments were the Ecology Achievement Test (EAT) and the Ecology Retention Test (ERT). Each instrument comprised 20 multiple-choice items covering selected ecological concepts identified for the study.

Validation and Reliability of the Instruments

The instruments underwent face and content validation by experts in Biology Education and Educational Technology. A pilot administration was conducted with students outside the study sample, and the reliability coefficient was estimated using Spearman-Brown Prophesy Test. The coefficient obtained was 0.73, indicating satisfactory internal consistency for the study.

Method of Data Collection

A pretest was administered to both groups before the treatment. The experimental group subsequently received instruction in selected difficult ecological concepts using an AI-powered personalized learning system, while the control group received instruction using the conventional lecture method. A posttest was administered immediately after the treatment. Two weeks after the posttest, a retention test was administered to both groups. Twenty minutes was allotted for each test administration.

Method of Data Analysis

Means and standard deviations were used to answer the research questions. Independent-samples t tests were used to test the null hypotheses at the 0.05 level of significance. Levene's test was used to assess the equality-of-variance assumption. The null hypothesis was rejected when $p < 0.05$ and retained when $p \geq 0.05$.

Results

Table 1

Pretest and Posttest Mean Achievement Scores by Instructional Group

Group	N	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Mean Gain
AI-powered personalized learning	20	10.90 (4.32)	13.85 (3.93)	2.95
Conventional method	20	9.70 (3.03)	12.25 (3.30)	2.55
Difference	—	1.20	1.60	0.40

Table 1 shows that the AI-powered personalized learning group had a higher posttest mean score (M = 13.85,SD=3.93) than the conventional group (M = 12.25,SD=3.30). The corresponding mean gains were 2.95 and 2.55, respectively.

Table 2

Levene's Test and Independent-Samples t-Test Results for Posttest Achievement Scores by Instructional Group

Groups compared: AI-powered personalized learning group (n = 20) and conventional-method group (n = 20).

Variance assumption	Levene's F	Levene's p	t	df	p	Mean difference	SE difference	95% CI lower	95% CI upper
Equal variances assumed	.474	.495	-1.39	38	.18	-1.6	1.2	-3.95	.746
Equal variances not assumed			-1.39	37.12	.18	-1.6	1.2	-3.98	.748

Levene's test was not significant, F = 0.474, p = 0.495, indicating that the equal-variance assumption was reasonable. The independent-samples t-test showed no statistically significant difference in posttest achievement, t(38) = -1.39, p = 0.18, 95% CI [-3.95, .746]. Therefore, $H0_1$ was retained.

Table 3

Mean Retention Scores by Instructional Group

Group	N	Mean	*SD*	SE
AI-powered personalized learning	20	16.45	2.58	0.57
Conventional method	20	11.55	3.47	0.78

Table 3 shows that the AI-powered personalized learning group recorded a higher mean retention score (M = 16.45,SD=2.58) against the conventional group (M = 11.55,SD=3.47).

Table 4
Levene's Test and Independent-Samples t-Test Results for Retention Scores by Instructional Group
Groups compared: AI-powered personalized learning group (n = 20) and conventional-method group (n = 20).

Variance assumption	Levene's F	Levene's p	t	df	p	Mean difference	SE difference	95% CI lower	95% CI upper
Equal variances assumed	.184	.183	-5.063	38	.000	-4.90	.968	-6.86	-2.94
Equal variances not assumed			-5.063	35.11	.000	-4.90	.968	-6.86	-2.94

Levene's test was not significant, F = 0.184, p = 0.183, indicating that the equal-variance assumption was reasonable. The independent-samples t-test showed a statistically significant difference in retention scores, t(38) = -5.063, p = 0.000, 95% CI [-6.86, -2.94]. As a result of that, $H0_2$ was rejected.

Discussion of Findings

The first finding showed that there was no statistically significant difference in the mean achievement scores of students taught ecology using AI-powered personalized learning and those taught using the conventional method. Although the AI group obtained a higher posttest mean score (M = 13.85,SD=3.93) than the conventional group (M = 12.25,SD=3.30), the difference was not statistically significant, t(38) = 1.39, p = 0.175. This result suggests that, within the duration and conditions of the present intervention, AI-powered personalized learning did not provide a statistically detectable advantage in immediate post-treatment achievement.

The finding is compatible with the broader literature indicating that the educational value of AI depends on how the technology is pedagogically integrated rather than on the presence of AI alone. Wang et al. (2024) reported substantial diversity in AI-in-education applications and research outcomes, while Mustafa et al. (2024) emphasized the need to examine educational context, implementation, and methodological quality when evaluating AI interventions. Almasri (2024) similarly concluded from empirical science-education research that AI has considerable potential, but its effects vary across learning contexts and applications.

The second finding revealed a statistically significant difference in retention. Students in the AI-powered personalized learning group recorded a mean retention score of (M=16.45,SD=2.58), compared with (M=11.55,SD=3.47) for the conventional group. The difference was statistically significant, t(38) = 5.06, p = 0.000. This indicates that the AI group retained substantially more of the ecological content after the two-week interval. The retention finding is consistent with evidence that learner-centred and technology-supported approaches can contribute to more durable biology learning. Onowugbeda et al. (2024) found a significant retention advantage for students taught through a culturally, technologically, and contextually oriented biology pedagogy in Nigeria. Similarly, Mahmud et al. (2022) reported that an alternative instructional strategy

produced better retention in secondary-school ecology than lecture-based instruction. The present study extends this line of evidence by indicating that an AI-powered personalized learning environment may also support retention of ecological concepts.

The result also aligns with the theoretical potential of personalized learning. Tapalova and Zhiyenbayeva (2022) describe AI-supported personalized learning as a framework through which intelligent technologies can provide learning experiences responsive to learners' needs. Farhood et al. (2025) found that AI-based personalized learning research commonly involves content recommendation, tutoring and support, and feedback and assessment. Such functions can allow learners to receive differentiated support and additional opportunities to interact with difficult concepts. Nevertheless, the present findings should be interpreted specifically as evidence of a retention advantage in this study rather than as proof that AI is universally superior to conventional teaching. The difference between the achievement and retention findings is particularly noteworthy. The AI group performed somewhat better immediately after instruction, but that difference did not reach statistical significance. The statistically significant difference emerged on the delayed retention measure. This suggests that the principal observed benefit of the intervention in the present study was the durability of learning rather than immediate posttest achievement. This distinction is important for biology education because students' ability to retain and retrieve ecological concepts after instruction is relevant to cumulative learning and subsequent application of knowledge.

Conclusion

The study concludes that AI-powered personalized learning did not produce a statistically significant difference in students' immediate achievement in ecology compared with the conventional teaching method. However, students exposed to AI-powered personalized learning demonstrated significantly higher retention scores than those taught using the conventional method. AI-powered personalized learning therefore shows promise as a complementary instructional approach for strengthening the retention of difficult ecological concepts among secondary-school students in Ugba Town.

Recommendations

The following recommendations were drawn from the study

1. Biology teachers should integrate appropriately selected AI-powered personalized learning tools with established classroom teaching practices when teaching difficult ecological concepts.
2. Schools and relevant education authorities should provide professional development that enables biology teachers to use AI tools pedagogically and responsibly.
3. AI-supported learning activities should be aligned with curriculum objectives and designed to provide individualized practice, feedback, revision, and opportunities for conceptual understanding.
4. Schools should strengthen access to appropriate digital devices, connectivity, and other infrastructure needed for technology-supported instruction.
5. Teachers should maintain pedagogical oversight and use AI as a complementary resource rather than as a replacement for teacher guidance.
6. Researchers should conduct additional studies with larger samples, longer intervention periods, and multiple secondary-school contexts to determine the robustness and generalizability of AI-supported personalized learning effects.

References

Almasri, F. (2024). Exploring the impact of artificial intelligence in teaching and learning of science: A systematic review of empirical research. *Research in Science Education*, *54*, 977–997. https://doi.org/10.1007/s11165-024-10176-3

Farhood, H., Nyden, *M*., Beheshti, A., & Muller, S. (2025). Artificial intelligence-based personalised learning in education: A systematic literature review. *Discover Artificial Intelligence*, *5*, Article 331. https://doi.org/10.1007/s44163-025-00598-x

Mahmud, A., Muhammad, I., & Ibrahim, S. (2022). The impact of field trip on the retention and academic performance in ecology among secondary school students in Zaria Local Government Area, Kaduna State. *Communication in Physical Sciences*, *8(2)*, 196–204.

Mustafa, *M*. Y., Tlili, A., Lampropoulos, G., Huang, R., Jandrić, P., Zhao, J., Salha, S., Xu, L., Panda, S., Kinshuk, López-Pernas, S., & Saqr, *M*. (2024). A systematic review of literature reviews on artificial intelligence in education (AIED): A roadmap to a future research agenda. *Smart Learning Environments*, *11*, Article 59. https://doi.org/10.1186/s40561-024-00350-5

Onowugbeda, F. U., Okebukola, P. A., Ige, A. *M*., Lameed, S. N., Agbanimu, D. O., & Adam, U. A. (2024). A cultural, technological, and contextual pedagogy to enhance retention of biology concepts. *The Journal of Educational Research*, *117(2)*, 49–60. https://doi.org/10.1080/00220671.2024.2324714

Tapalova, O., & Zhiyenbayeva, N. (2022). Artificial intelligence in education: AIEd for personalised learning pathways. *The Electronic Journal of e-Learning*, *20(5)*, 639–653. https://doi.org/10.34190/ejel.20.5.2597

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications*, *252*, Article 124167. https://doi.org/10.1016/j.eswa.2024.124167

Yim, I. H. Y., & Su, J. (2025). Artificial intelligence (AI) learning tools in K–12 education: A scoping review. *Journal of Computers in Education*, *12*, 93–131. https://doi.org/10.1007/s40692-023-00304-9