E-ISSN: 1115 - 8425 P-ISSN: 3027-012X
MPRI-JAEE | INTERNATIONAL JOURNAL OF ASSESSMENT & EVALUATION IN EDU.
VOL. 12 NO. 8 – APRIL. 2026

ASSESSMENT OF ARTIFICIAL INTELLIGENCE POWERED TUTORING SYSTEM ON STUDENTS LEARNING OUTCOMES AMONG ADOLESCENTS IN THE EDUCATION DISTRICT IV OF LAGOS STATE, NIGERIA

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DOI: https://doi.org/10.70382/mejaee.v12i8.0107

Keywords: AI-powered tutoring system, Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment, Automated Scoring System, Learning outcomes.

Abstract

AI-powered tutoring systems are innovative instructional tools that provide personalized and adaptive learning experiences for students. For adolescents in Education District IV of Lagos State, these systems have the potential to enhance understanding, engagement and academic performance. Examining their impact on students' learning outcomes is essential for informing the effective integration of AI technologies into secondary school education. This study used descriptive study design. Three hundred and seventy-one (371) students participated in the study. A self-structured questionnaire title "AI-Powered Tutoring System and Learning Outcomes Questionnaire (AIT-L-Q) was used for the study. Five hypotheses were raised and tested for this study. Results obtained showed and revealed that Intelligent Tutoring Systems, Virtual Learning Environment, Automated Scoring systems and Adaptive Learning Systems each had a significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State. Based on the findings, recommendations indicated that Intelligent Tutoring Systems, strengthen Virtual Learning Environment, implement Automated Scoring and Adaptive Learning Systems, and that the Lagos State Ministry of Education develop a framework to support their integrated use.

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Introduction

Artificial Intelligence (AI) has become a transformative force in global education, offering personalised learning, immediate feedback, and support for differentiated instruction. According to Kumar, Singh, and Gupta (2021), AI's integration into education has evolved from a futuristic concept to a practical tool applied in classrooms and online learning environments. They highlight that AI technologies, particularly intelligent tutoring systems (ITS), adaptive learning systems, virtual learning environments (VLEs), and automated scoring, have significant potential to automate routine instructional processes, provide adaptive learning experiences, and assist teachers in monitoring student progress. This evolution has laid the foundation for a new era of technology-enhanced learning in both developed and developing nations.

In Nigeria, interest in AI-driven education is rapidly growing. Gambaro, Thomas, and Ojo (2021) note that while AI applications in education are still at a nascent stage locally, awareness among educators regarding its potential benefits is increasing. Their review highlights early pilot projects where AI systems were used to deliver personalised learning in science and mathematics courses, reporting improvements in students' performance and motivation. They further emphasize the need for empirical evidence from large-scale interventions to guide policymakers on the effective integration of AI tools into school systems.

A particularly promising application of AI in education is AI-powered tutoring systems, which combine machine learning algorithms and natural language processing to create individualised learning paths. Ouyang, Zhang, and Wang (2023) provide evidence that such systems can significantly enhance learning outcomes by diagnosing student errors, adjusting content difficulty, and offering immediate corrective feedback. Their study reveals that students who engaged with ITS more frequently achieved higher mastery of learning objectives compared with peers receiving traditional instruction, underscoring the importance of consistent usage for optimal results.

Central to AI tutoring is the principle of personalisation. Almalki, Alzahrani, and Alshahrani (2022), in their systematic review, observed that personalised learning environments powered by AI lead to improved academic outcomes across multiple disciplines. They explain that AI systems create dynamic learner profiles, enabling the recommendation of tailored instructional content and exercises. Such adaptivity is particularly advantageous for adolescents, who often exhibit diverse learning needs and attention spans.

Lin and Mubarok (2021) elaborate on the pedagogical mechanisms behind AI personalisation, reporting that adaptive sequencing, metacognitive prompting, and step-by-step guidance embedded in AI platforms are highly effective in fostering deeper understanding and knowledge transfer. These features are crucial for helping adolescents

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progress beyond rote memorisation towards the development of problem-solving and critical thinking skills, which are essential in today's knowledge economy.

A critical pathway through which AI systems enhance student achievement is increased learner engagement. AlZu'bi, Al-Sharif, and Al-Mahadin (2022) demonstrate that students interacting with AI tutors show higher behavioural and cognitive engagement, which mediates their academic success. Features such as gamification, real-time feedback, and progress tracking sustain students' attention and encourage persistence in learning tasks, particularly important for adolescents who may struggle with motivation and focus in traditional classrooms.

Beyond cognitive outcomes, AI-assisted learning also has psychosocial benefits. Zhu (2024) finds that AI-supported teaching reduces test anxiety and boosts students' confidence through its non-judgemental, adaptive feedback loops. Students reported feeling more in control of their learning and experiencing lower stress levels during assessment preparation. These psychological benefits are crucial during adolescence, a developmental stage marked by heightened emotional sensitivity and self-concept formation.

Local studies in Nigeria are beginning to reflect similar trends. Adedokun and Olabode (2024) explored AI-powered tutoring systems for personalised English language learning among Colleges of Education students in Lagos State. Their study reported positive student attitudes, improved vocabulary acquisition, and higher engagement during practice sessions. They also highlighted the importance of aligning AI content with Nigeria's curriculum standards and providing teacher support to ensure smooth implementation.

Moreover, Ubabuike and Nweke (2025) observed statistically significant improvements in academic performance among public secondary school students exposed to AI-assisted learning interventions. Their findings suggest that AI can narrow performance gaps when supported by proper teacher guidance and infrastructure, offering a model for scaling technology-based instruction across school districts. Thomas and Gambari (2022) further noted that AI technologies were most effective when combined with teacher coaching and curriculum-aligned lesson planning. Students in blended learning environments that integrated AI systems with classroom instruction outperformed those in fully traditional settings, reinforcing the argument that AI tutoring systems should complement rather than replace teachers.

Globally, scholars have highlighted ethical and equity challenges associated with AI in education. Swargiary (2024) cautions that AI deployments risk deepening the digital divide if access to devices, connectivity, and digital skills is unequal. He advocates inclusive implementation strategies, such as offline functionality and targeted support for low-income learners, to prevent exacerbation of educational inequalities. These

considerations are particularly relevant in Lagos State, where disparities in resource availability persist.

Despite its promise, AI integration in schools is not without challenges. Kumar, Singh, and Gupta (2021) highlight risks such as algorithmic bias, data privacy concerns, and over-reliance on technology. They recommend robust data governance frameworks, teacher oversight, and continuous monitoring of AI performance to mitigate potential harms. Addressing these risks is essential for the safe and effective deployment of AI tutoring systems in Education District IV.

Moreover, Kestin, Miller, Klales, Milbourne & Ponti (2025) indicated that ITS positively impacts student learning and performance in K-12 education, emphasising the importance of system design and proper implementation. Similarly, Létourneau, Deslandes Martineau, Charland, Karran, Boasen & Léger (2025) reported that AI-powered learning tools significantly improve student understanding, academic performance, engagement, and motivation. Compared with traditional in-class active learning, Vieriu & Petrea (2025) found that students using AI tutors learned more efficiently and felt more engaged, highlighting the potential of AI systems to complement conventional teaching methods.

Finally, the growing global and local evidence base, coupled with Nigeria's strategic education objectives, provides a strong rationale for examining the impact of AI-powered tutoring systems on students' learning outcomes among adolescents in Education District IV of Lagos State. By generating context-specific findings, this study aims to contribute to evidence-based decision-making on how best to harness AI to improve learning outcomes and foster equitable, inclusive education for all (Adedokun & Olabode, 2024; Ouyang, Zhang, & Wang, 2023; Zhu, 2024.

Statement of the Problem

Despite the global rise of Artificial Intelligence (AI) in education, the use of AI-powered tutoring systems, such as Intelligent Tutoring Systems (ITS), Adaptive Learning Systems, Virtual Learning Environments (VLEs), and Automated Scoring, remains limited in Nigerian secondary schools, particularly within Education District IV of Lagos State. Most schools continue to rely on traditional teaching methods that inadequately address the diverse learning needs of adolescents, leading to challenges such as insufficient individualised attention, delayed feedback, and difficulty mastering complex subjects, especially in STEM and language disciplines. Consequently, students experience uneven academic outcomes, reduced engagement, and lower motivation during a critical stage of cognitive, social, and emotional development.

The limited adoption of AI tools is further compounded by teacher preparedness and infrastructure issues. Many educators lack adequate training to implement ITS, adaptive learning platforms, VLEs, or automated scoring systems effectively. Simultaneously,

schools often face shortages of computers, unreliable internet access, and insufficient licensed software, all of which hinder the integration of technology-supported learning. These factors collectively reduce the potential benefits of AI-powered systems and restrict the ability of students to experience personalised, adaptive learning environments.

Moreover, there is a scarcity of local empirical research on the effectiveness of AI-powered educational tools in Nigerian secondary schools. While international studies indicate that ITS, adaptive learning systems, and other AI platforms can improve learning outcomes, engagement, and assessment accuracy, it remains unclear whether these benefits are replicable for adolescents in Lagos State. This lack of context-specific evidence, combined with gaps in teacher training, resource limitations, and policy constraints, poses a significant barrier to informed decision-making and the successful integration of AI into the curriculum.

Purpose of the Study

This study seeks to:

i. Investigate the impact of Intelligent Tutoring Systems (ITS) on students' learning outcomes in secondary schools within Education District IV.
ii. Assess the impact of Virtual Learning Environments (VLEs) on students' learning outcomes in secondary schools within Education District IV
iii. Explore the impact of Automated Scoring on students' learning outcomes in secondary schools within Education District IV
iv. Examine the impact of Adaptive Learning Systems on students' learning outcomes in secondary schools within Education District IV
v. Explore the combined impact of these AI-powered tutoring systems on overall learning outcomes among secondary school adolescents.

Research Questions

This study seeks to answer the following research questions:

a) To what extent do Intelligent Tutoring Systems (ITS) affect students' learning outcomes in secondary schools within Education District IV of Lagos State?
b) How do Virtual Learning Environments (VLEs) influence students' learning outcomes in secondary schools within Education District IV of Lagos State?
c) How effective are Automated Scoring in improving students' learning outcomes in secondary schools within Education District IV of Lagos State?
d) To what extent do adaptive learning systems impact students' learning outcomes in secondary schools within Education District IV of Lagos State?

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e) What is the overall effect of integrating ITS, Adaptive Learning Systems, VLEs, and Automated Scoring on the learning outcomes of secondary school students?

Research Hypotheses

The following null hypotheses will guide the study and will be tested at a 0.05 level of significance:

H_{01}: Intelligent Tutoring Systems (ITS) have no significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State.

H_{02}: Virtual Learning Environments (VLEs) have no significant influence on students' learning outcomes in secondary schools within Education District IV of Lagos State.

H_{03}: Automated Scoring systems do not significantly impact students' learning outcomes in secondary schools within Education District IV of Lagos State.

H_{04}: Adaptive learning systems have no significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State.

H_{05}: The integration of ITS, Adaptive Learning Systems, VLEs, and Automated Scoring does not significantly improve the overall learning outcomes of secondary school students in Education District IV of Lagos State

Research Design

This study adopted a descriptive survey research design to examine the impact of AI-powered tutoring systems on students' learning outcomes in secondary schools within Education District IV of Lagos State. The survey design was considered appropriate because it allowed for the systematic collection of self-reported data from students regarding their perceptions, experiences, and frequency of use of AI tools (Creswell & Creswell, 2018). The study was geographically confined to Education District IV of Lagos State, Nigeria, with a focus on secondary schools within the district. Education District IV was selected because it comprised a diverse range of schools with varying levels of infrastructure, teacher preparedness, and access to technological resources, making it suitable for examining the impact of AI-powered tutoring systems. The population of the study comprised adolescent students in secondary schools within Education District IV of Lagos State. A stratified random sampling technique was adopted to ensure adequate representation across the three LGAs, with each LGA treated as a distinct stratum. Proportional allocation was applied by determining the percentage contribution of each LGA to the total population, resulting in 57.1% for Surulere, 23.2% for Lagos Mainland, and 19.7% for Apapa. These proportions were applied to a sample size of 400 respondents, yielding 228 students from Surulere, 93 from Lagos Mainland, and 79 from Apapa. Simple random sampling was then used to select respondents within each LGA, ensuring that every student had an equal chance of participation.

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Research Instrument

Data for the study were collected using a self-structured questionnaire titled "*AI-Powered Tutoring System and Learning Outcomes Questionnaire (AIT-L-Q)*". The questionnaire consisted of two sections. Section A captured respondents' demographic information, including age, gender, and class level. Section B obtained self-reported data on students' perceptions, experiences, and frequency of use of AI tools such as Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environments, and Automated Scoring Systems, measured on a 4-point Likert scale. In addition, a 25-item multiple-choice Mathematics Achievement Test with four response options was administered to objectively measure students' learning outcomes.

Data Analysis

Data collected from the structured questionnaires were coded and entered into the Statistical Package for Social Sciences (SPSS) version 22 for analysis. Descriptive statistics, including frequencies and percentages, were used to summarize respondents' demographic characteristics. Regression analysis was employed to test all generated hypotheses at the 5% level of significance.

Results

Data were analyzed based on the following: Demographic, Characteristics of the Participants Response to questionnaire, Testing of hypotheses, Summary of Findings, Discussion of Findings.

Table 1: Demographic Characteristics of Students

Variables	Frequency	Percentage
Gender:		
Male	149	47.0
Female	168	53.0
Total	**317**	**100.0**
Age (years):		
12-14	109	34.4
15-17	131	41.3
Above 17	77	24.3
Total	**317**	**100.0**
Class level:		
JSSI	68	21.5

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Variables	Frequency	Percentage
JSSII	81	25.6
JSSIII	23	7.3
SSSI	73	23.0
SSSII	61	19.2
SSSIII	11	3.4
Total	317	100.0

Concerning gender as indicated in Table 1, 47% of the participants were male students, while 53% of them were female students. Hence, female students participated more in this study.

With respect to age, 34.4% of the participants were within 12-14 years of age, 41.3% of them were within 15-17 years of age, while 24.3% of them were above 17 years of age. Hence, students within 15-17 years of age participated mostly in this study.

Regarding class level, Table 1 showed that 21.5% of the students were from JSSI, 25.6% of theM were from JSSII, 7.3% of them were from JSSIII, 23% of them were from SSSI, 19.2% of them were from SSSII, while 3.4% of them were from SSSIII. Hence, JSSII students participated mostly in this study Reponse to Questionnaire.

Table 2: Intelligent Tutoring Systems (ITS) Usage

	Statements	SA	A	D	SD	Total
1	I regularly use Intelligent Tutoring Systems to learn my subjects.	112 (35.3%)	137 (43.2%)	44 (13.9%)	24 (7.6%)	317 (100%)
2	ITS helps me understand difficult concepts better.	124 (39.1%)	141 (44.5%)	32 (10.1%)	20 (6.3%)	317 (100%)
3	ITS provides immediate feedback that improves my learning.	131 (41.3%)	138 (43.5%)	29 (9.1%)	19 (6.0%)	317 (100%)
4	I feel more confident in my lessons when I use ITS	118 (37.2%)	139 (43.9%)	37 (11.7%)	23 (7.3%)	317 (100%)
5	ITS makes learning more engaging compared to traditional methods	129 (40.7%)	133 (41.9%)	34 (10.7%)	21 (6.6%)	317 (100%)

The results indicate a generally **high level of usage and positive perception** of Intelligent Tutoring Systems (ITS) among the 317 participants. For the first statement, as revealed in Table 2, "*I regularly use Intelligent Tutoring Systems to learn my subjects,*" a large majority

of respondents, **249 (78.5%)**, either strongly agreed or agreed, suggesting that ITS has become a commonly used learning tool among the students. Only **21.5%** expressed disagreement, indicating that regular ITS usage is widespread. Regarding understanding difficult concepts, **265 (83.6%)** of the participants agreed that ITS helps them grasp challenging topics better. This shows that ITS plays an important role in enhancing conceptual understanding and supporting academic learning. Similarly, **269 (84.8%)** of the respondents agreed that ITS provides immediate feedback that improves their learning. This highlights the effectiveness of ITS in offering timely responses, which can help learners correct mistakes and reinforce understanding. On students' confidence, **257 (81.1%)** agreed that they feel more confident in their lessons when using ITS. This suggests that ITS not only supports academic performance but also contributes positively to students' self-confidence. Finally, **262 (82.6%)** of the participants agreed that ITS makes learning more engaging compared to traditional methods. This implies that ITS enhances learner engagement, possibly through interactive features and personalized instruction. Hence, the findings reveal that Intelligent Tutoring Systems are **widely used**, **effective**, and **well-accepted** by students.

Table 3: Virtual Learning Environments (VLEs) Usage

	Statements	SA	A	D	SD	Total
1	I actively participate in Virtual Learning Environments provided by my school.	115 (36.3%)	139 (43.9%)	41 (12.9%)	22 (6.9%)	317 (100%)
2	VLEs provide resources that help me complete assignments effectively.	127 (40.1%)	136 (42.9%)	33 (10.4%)	21 (6.6%)	317 (100%)
3	VLEs improve my collaboration with teachers and classmates.	121 (38.2%)	134 (42.3%)	39 (12.3%)	23 (7.3%)	317 (100%)
4	Using VLEs has increased my interest in learning.	118 (37.2%)	138 (43.5%)	37 (11.7%)	24 (7.6%)	317 (100%)
5	VLEs allow me to learn at my own pace.	132 (41.6%)	133 (41.9%)	31 (9.8%)	21 (6.6%)	317 (100%)

The results in Table 3 indicate that the majority of the 317 participants have positive experiences and perceptions regarding the use of Virtual Learning Environments (VLEs) in their academic activities. For the first statement, "I actively participate in Virtual Learning Environments provided by my school," 254 respondents (80.2%) either strongly agreed or agreed. This suggests that students are not only enrolled in VLE platforms but also actively engage with the tools and resources provided. Regarding assignment

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completion, 263 respondents (83.0%) agreed that "VLEs provide resources that help me complete assignments effectively." This indicates that VLEs are perceived as valuable tools for accessing learning materials, guidance, and resources necessary to perform academic tasks successfully. On collaboration, 255 respondents (80.5%) agreed that "VLEs improve my collaboration with teachers and classmates." This shows that VLEs facilitate communication and cooperative learning, enabling students to interact more efficiently with peers and instructors. Similarly, 256 respondents (80.8%) agreed that "Using VLEs has increased my interest in learning." This implies that the interactive and multimedia features of VLEs enhance learner engagement and motivation. Finally, 265 respondents (83.5%) agreed that "VLEs allow me to learn at my own pace." This demonstrates that VLEs support self-directed learning, enabling students to review materials, complete tasks, and study according to their individual learning speed and convenience.
Hence, the findings reveal that Virtual Learning Environments are widely used, effective, and positively perceived by students.

Table 4: Adaptive Learning Systems Usage

	Statements	SA	A	D	SD	Total
1	Adaptive learning systems tailor content according to my learning level.	128 (40.4%)	135 (42.6%)	33 (10.4%)	21 (6.6%)	317 (100%)
2	I feel that adaptive systems help me focus on topics I find difficult.	122 (38.5%)	137 (43.2%)	36 (11.4%)	22 (6.9%)	317 (100%)
3	Adaptive systems adjust learning activities to suit my pace.	130 (41.0%)	133 (42.0%)	32 (10.1%)	22 (6.9%)	317 (100%)
4	Using adaptive systems increases my motivation to learn.	119 (37.5%)	138 (43.5%)	37 (11.7%)	23 (7.3%)	317 (100%)
5	Adaptive systems help me track my learning progress effectively	126 (39.7%)	136 (42.9%)	34 (10.7%)	21 (6.6%)	317 (100%)

The results in Table 4 show that the majority of the 317 participants hold positive perceptions and experiences with adaptive learning systems. For the first statement, "Adaptive learning systems tailor content according to my learning level," 263 respondents (83.0%) either strongly agreed or agreed. This suggests that adaptive learning systems are perceived as effective tools for providing personalized learning

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content that matches individual student needs. Regarding focus on difficult topics, 259 respondents (81.7%) agreed that adaptive systems help them concentrate on areas they find challenging. This indicates that adaptive systems provide targeted support, allowing students to allocate more attention to topics requiring extra effort. Similarly, 263 respondents (83.0%) agreed that adaptive systems adjust learning activities to suit their pace. This reflects the flexibility of adaptive learning systems, enabling students to learn at a speed that is comfortable for them without feeling rushed or left behind. On motivation, 257 respondents (81.0%) agreed that using adaptive systems increases their motivation to learn. This implies that personalized learning paths and adaptive feedback enhance engagement and encourage students to remain committed to their studies. Finally, 262 respondents (82.7%) agreed that adaptive systems help them track their learning progress effectively. This shows that adaptive systems are valued for their ability to monitor performance, provide insights, and guide learners toward achieving their learning goals.

Hence, the findings indicate that adaptive learning systems are highly effective and positively perceived by students.

Table 5: Automated Scoring Systems Usage

	Statements	SA	A	D	SD	Total
1	Automated scoring systems provide timely feedback on my performance.	129 (40.7%)	134 (42.3%)	33 (10.4%)	21 (6.6%)	317 (100%)
2	I correct my mistakes promptly due to feedback from automated scoring.	124 (39.1%)	137 (43.2%)	35 (11.0%)	21 (6.6%)	317 (100%)
3	Automated scoring helps me practice more effectively.	131 (41.3%)	132 (41.6%)	33 (10.4%)	21 (6.6%)	317 (100%)
4	Using automated scoring increases my confidence in exams and assignments.	120 (37.9%)	139 (43.9%)	36 (11.4%)	22 (6.9%)	317 (100%)
5	Automated scoring systems motivate me to improve my learning outcomes	127 (40.1%)	135 (42.6%)	34 (10.7%)	21 (6.6%)	317 (100%)

The results in Table 5 indicate that the majority of the 317 participants hold **positive perceptions** toward the use of automated scoring systems in their learning process. For the first statement, *"Automated scoring systems provide timely feedback on my performance,"* **263 respondents (83.0%)** either strongly agreed or agreed, showing that

students value the speed at which feedback is delivered through automated systems. This suggests that such systems help learners quickly understand their performance. Regarding error correction, **261 respondents (82.3%)** agreed that they correct their mistakes promptly due to feedback from automated scoring. This implies that automated feedback supports immediate learning improvement and encourages students to address their weaknesses quickly. Similarly, **263 respondents (82.9%)** agreed that automated scoring helps them practice more effectively. This indicates that the system enhances learning efficiency by guiding students during practice activities. On confidence, **259 respondents (81.8%)** agreed that using automated scoring increases their confidence in exams and assignments. This suggests that consistent feedback helps students feel better prepared and more assured in academic assessments. Finally, **262 respondents (82.7%)** agreed that automated scoring systems motivate them to improve their learning outcomes. This shows that automated scoring not only supports performance monitoring but also encourages continuous academic improvement. Hence, the findings reveal that automated scoring systems play a **significant and positive role** in students' learning outcomes.

Hypothesis One

Intelligent Tutoring Systems (ITS) have no significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State. This was tested using regression analysis and the result is presented in Table 6, 7 and 8 below:

Table 6: Regression Summary showing the goodness of fit of the model to explain the variability in the learning outcomes.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.615[a]	.378	.376	2.715	.378	191.731	1	315	.000

P<0.05; F(1, 315) = 3.87

From the table, R^2 = 0.378 value showed a good level of fit, because F-change of 191.731 is more than the critical value F(1, 315) = 3.87 at 0.05 level of significance, which resulted in the rejection of null hypothesis. This suggests that there is good fit between regression model and the learning outcomes. Hence, the model is valid. Similarly, it implies that 37.8% of the learning outcomes was explained by the Intelligent Tutoring Systems (ITS).

Table 7: ANOVA table showing impact of Intelligent Tutoring Systems (ITS) have no significant impact on students' learning outcomes.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1413.771	1	1413.771	191.731	.000[b]
Residual	2322.722	315	7.374		
Total	3736.492	316			

P<0.05; F(1, 315) = 3.87

The above results in Table 7 showed there is significant impact of Intelligent Tutoring Systems (ITS) have no significant impact on students' learning outcomes. This result is significant, because the calculated F-value of 191.731 is more than the critical value F(1, 315) = 3.87 at 0.05 level of significance. Hence, Intelligent Tutoring Systems (ITS) have a significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State, because null hypothesis was rejected.

Table 8: Coefficient table showing impact of Intelligent Tutoring Systems (ITS) have no significant impact on students' learning outcomes.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	5.033	.846		5.953	.000
Intelligent tutoring system	.841	.061	.615	13.847	.000

From the above table, the coefficient estimates of (β = 0.841, P = 0.000<0.05) revealed that Intelligent tutoring system is positively correlated with learning outcomes of students. It also implies that a unit increase in intelligent tutoring system will increase learning outcomes of students by a magnitude of 0.841.

Hypothesis Two

Virtual Learning Environments (VLEs) have no significant influence on students' learning outcomes in secondary schools within Education District IV of Lagos State. This was tested using regression analysis and the result is presented in Table 9, 10 and 11 below:

Table 9: Regression Summary showing the goodness of fit of the model to explain the variability in the learning outcomes.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.214[a]	.046	.043	3.364	.046	15.181	1	315	.000

P<0.05; F(1, 315) = 3.87

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From the table, R^2 = 0.046 value showed a good level of fit, because F-change of 15.181 is +more than the critical value F(1, 315) = 3.87 at 0.05 level of significance, which resulted in the rejection of null hypothesis. This suggests that there is good fit between Virtual Learning Environments (VLEs) model and the learning outcomes. Hence, the model is valid. Similarly, it implies that 4.6% of the learning outcomes was explained by the Virtual Learning Environments (VLEs).

Table 10: ANOVA table showing influence of the Virtual Learning Environments (VLEs) on students' learning outcomes

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	171.797	1	171.797	15.181	.000[b]
Residual	3564.696	315	11.316		
Total	3736.492	316			

P<0.05; F(1, 315) = 3.87

The above results in Table 10 showed there is significant influence of the Virtual Learning Environments (VLEs) on students' learning outcomes. This result is significant, because the calculated F-value of 15.181 is more than the critical value F(1, 315) = 3.87 at 0.05 level of significance. Hence, Virtual Learning Environments (VLEs) have significant influence on students' learning outcomes in secondary schools within Education District IV of Lagos State, because null hypothesis was rejected.

Table 11: Coefficient table showing influence of Virtual Learning Environments (VLEs) on students' learning outcomes

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	13.124	.899		14.598	.000
Virtual learning environment	.258	.066	.214	3.896	.000

From the above table, the coefficient estimates of (β = 0.258, P = 0.000<0.05) revealed that Virtual learning environment is positively correlated with learning outcomes of students. It also implies that a unit increase in Virtual learning environment will increase learning outcomes by a magnitude of 0.258.

Hypothesis Three

Automated Scoring Systems do not significantly impact students' learning outcomes in secondary schools within Education District IV of Lagos State. This was tested using regression analysis and the result is presented in Table 12, 13 and 14 below:

Table 12: Regression Summary showing the goodness of fit of Automated Scoring Systems model to explain the variability in the learning outcomes.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.233[a]	.054	.051	3.349	.054	18.144	1	315	.000

P<0.05; F(1, 315) = 3.87

From the table, R^2 = 0.054 value showed a good level of fit, because F-change of 18.144 is greater than the critical value F(1, 315) = 3.87 at 0.05 level of significance, which resulted in the rejection of null hypothesis. This suggests that there is good fit between regression model and the learning outcomes. Hence, the model is valid. Similarly, it implies that 5.4% of the learning outcomes were explained by the Automated Scoring Systems.

Table 13: ANOVA table showing impact of Automated Scoring Systems on students' learning outcomes in secondary schools

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	203.505	1	203.505	18.144	.000[b]
Residual	3532.987	315	11.216		
Total	3736.492	316			

P<0.05; F(1, 315) = 3.87

The above results in Table 13 showed there there is significant impact of the Automated Scoring Systems on students' learning outcomes. This result is significant, because the calculated F-value of 18.144 is more than the critical value F(1, 315) = 3.87 at 0.05 level of significance. Hence, Automated Scoring Systems have significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State, because null hypothesis was rejected.

Table 14: Coefficient table showing impact of Automated Scoring Systems on students' learning outcomes

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	11.830	1.124		10.527	.000
Automated scoring system	.347	.082	.233	4.260	.000

From the above table, the coefficient estimates of (β = 0.347, P = 0.000<0.05) revealed that Automated Scoring System is positively correlated with learning outcomes of

students. It also implies that a unit increase in Automated Scoring System will increase learning outcomes by a magnitude of 0.347.

Hypothesis Four

Adaptive learning systems have no significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State. This was tested using regression analysis and the result is presented in Table 15, 16 and 17 below:

Table 15: Regression Summary showing the goodness of fit of Adaptive learning system model to explain the variability in the learning outcomes.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.266[a]	.071	.068	3.320	.071	23.972	1	315	.000

P<0.05; F(1, 315) = 3.87

From the table, R^2 = 0.071 value showed a good level of fit, because F-change of 23.972 is greater than the critical value F(1, 315) = 3.87 at 0.05 level of significance, which resulted in the rejection of null hypothesis. This suggests that there is good fit between regression model and the learning outcomes. Hence, the model is valid. Similarly, it implies that 7.1% of the learning outcomes was explained by the Adaptive learning system

Table 16: ANOVA table showing impact of Adaptive learning system on students' learning outcomes in secondary schools

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	264.248	1	264.248	23.972	.000[b]
Residual	3472.244	315	11.023		
Total	3736.492	316			

P<0.05; F(1, 315) = 3.87

The above results in Table 16 showed there there is significant impact of the Adaptive learning system on students' learning outcomes. This result is significant, because the calculated F-value of 23.972 is more than the critical value F(1, 315) = 3.87 at 0.05 level of significance. Hence, Adaptive learning system has a significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State, because null hypothesis was rejected.

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Table 17: Coefficient table showing impact of Adaptive learning system on students' learning outcomes in secondary schools

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	12.847	.779		16.498	.000
Adaptive learning system	.325	.066	.266	4.896	.000

From the above table, the coefficient estimate of ($\beta = 0.325$, $P = 0.000 < 0.05$) revealed that Adaptive learning system is positively correlated with learning outcomes of students. It also implies that a unit increase in Adaptive learning system will increase learning outcomes by a magnitude of 0.325

Hypothesis Five

The integration of Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System does not significantly improve the overall learning outcomes of secondary school students in Education District IV of Lagos State. This hypothesis was tested using multiple regression analysis and the result is presented in Table 18, 19 and 20 below:

Table 18: Regression Summary showing the goodness of fit of the integration of Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System model to explain the variability in the learning outcomes.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
.647[a]	.418	.411	2.639	.418	56.130	4	312	.000

$P < 0.05$; $F(4, 312) = 2.40$

From the table, $R^2 = 0.418$ value showed a good level of fit, because F-change of 56.130 is greater than the critical value $F(4, 312) = 2.40$ at 0.05 level of significance, which resulted in the rejection of null hypothesis. This suggests that there is good fit between regression model and the learning outcomes. Hence, the model is valid. Similarly, it implies that 41.8% of the learning outcomes was explained by the Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System.

Table 19: ANOVA table showing impact of Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System on students' learning outcomes in secondary schools

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1563.633	4	390.908	56.130	.000[b]
Residual	2172.860	312	6.964		
Total	3736.492	316			

P<0.05; F(4, 312) = 2.40

The above results in Table 19 showed there is a significant influence of Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System on learning outcomes. This result is significant, because the calculated F-value of 56.13 is greater than the critical value F(4, 312) = 2.40 at 0.05 level of significance. Hence, the integration of Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System significantly improves learning outcomes, because null hypothesis was rejected.

Table 20: Coefficient table showing influence of Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System on learning outcomes

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.437	1.220		1.997	.047
Intelligent tutoring system	.799	.065	.587	12.370	.000
Virtual learning environment	.003	.056	.002	.054	.957
Adaptive learning system	.144	.056	.118	2.584	.010
Automated scoring system	.111	.068	.075	1.637	.103

From the above table, the coefficient estimates of (β = 0.799, P = 0.000<0.05, β = 0.003, P = 0.957>0.05, β = 0.144, P = 0.010<0.05 and β = 0.111, P = 0.103>0.05) revealed that Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System on learning outcomes are positively correlated with learning outcomes of students. Meanwhile, Intelligent Tutoring Systems and Adaptive Learning Systems are significantly correlated with learning outcomes of students, while

Virtual Learning Environment and Automated Scoring System aren't significantly correlated. It also implies that a unit increase in Intelligent Tutoring Systems, Adaptive Learning Systems, Virtual Learning Environment and Automated Scoring System will increase learning outcomes of students by a magnitude of 0.799, 0.144, 0.003 and 0.111 respectively.

Discussion of the Findings

Findings from hypothesis one revealed that Intelligent Tutoring Systems (ITS) have a significant impact on students' learning outcomes in secondary schools within Education District IV of Lagos State. The findings revealed a positive influence of ITS on students' academic performance, understanding of difficult concepts, confidence, and engagement in learning activities. This suggests that the use of ITS contributes meaningfully to improving learning outcomes among secondary school students in the study area. This finding aligns with Akyuz (2020), who reported that ITS significantly improves student performance by providing personalized instructional support tailored to individual learning needs and pacing. Akyuz also emphasized that ITS enhances time management and prevents learner frustration by offering appropriate challenges, thereby promoting more effective learning experiences.

The result is also consistent with Al-Aqbi, Saedi, and Saleh (2019), who found that ITS significantly enhances student learning outcomes compared to traditional teaching methods. Their study highlighted that ITS addresses diverse learning styles and preparation levels through personalized instruction, which improves student engagement, comprehension, and academic performance. Similarly, the present finding supports Ilić, Ivanovic, and Milicevic (2024), who demonstrated that AI-enhanced ITS positively influences student motivation and academic achievement in STEM education. They noted that ITS provides timely feedback and individualized learning experiences that foster active engagement and improve learning outcomes. In addition, the result agrees with Létourneau et al. (2025), who found that ITS can enhance academic performance in K–12 settings, particularly when implementation quality, subject domain, and instructional design are carefully aligned with curriculum goals. Their study emphasized that well-structured ITS deployment leads to more reliable improvements in student achievement. Furthermore, the finding is in line with Wang et al. (2023), whose meta-analysis revealed that ITS can improve students' comprehension, motivation, and problem-solving skills when effectively integrated into real classroom contexts with adequate teacher guidance and technological support. They stressed that ITS works best when it complements traditional instruction rather than replacing it.

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The present result also agrees with Kestin et al. (2025), who found that students using AI-powered tutoring systems achieved greater learning gains and higher engagement than those in traditional active learning classrooms. The adaptive feedback and personalized learning paths provided by AI tutors helped students master complex concepts more quickly. Likewise, Fodouop Kouam (2024) confirmed that ITS significantly improves students' conceptual understanding, debugging skills, and problem-solving abilities in programming education. The study showed that ITS helps bridge performance gaps between novice and advanced learners through adaptive feedback mechanisms.

Finally, the finding strongly supports Ugorji, Ezinwa, and Nnalue (2025), who reported that secondary school students taught with ITS in Imo State performed significantly better in mathematics than those taught using traditional methods. Their study demonstrated significant improvements in post-test scores following ITS intervention, highlighting the effectiveness of ITS in Nigerian secondary school contexts.

Findings from hypothesis two revealed that Virtual Learning Environments (VLEs) significantly influence students' learning outcomes in secondary schools within Education District IV of Lagos State. The results from this study indicate that participants have a generally positive perception of, and experience with, VLEs, suggesting meaningful influence on their academic engagement and performance. This finding is consistent with research by Ademola (2021), who found significant positive correlations between VLE satisfaction, academic performance, and engagement. In that study, students who reported higher satisfaction with their VLEs also tended to achieve better academic outcomes, highlighting the role of engagement as a mediator in enhancing learning effectiveness. Similarly, Barker and Gossman (2013) reported in their study that the use of a VLE (specifically Moodle) produced improvements in students' learning and motivation to learn, indicating that VLEs support effective learning processes and foster student interest. The influence of VLEs on student satisfaction and affective learning is also supported by Yin, Zhang, Li & Luo (2024) showing that positive attitudes toward VLEs are linked to higher satisfaction with the learning experience, which in turn can enhance academic engagement and perceived learning success.

Further evidence from Shatri & Kelmendi (2023) suggests that virtual classrooms and VLE-based instructional strategies are correlated with improved academic outcomes. According to the authors, students often experience increased participation, attention, and academic achievement when learning through virtual classroom environments compared to traditional formats. However, while the positive influence of VLEs is broadly supported, research by Ryan & Poole (2019) suggests

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that the impact on long-term retention or performance may vary depending on context, instructional quality, and integration with traditional teaching methods. For instance, randomized trials noted improved engagement and recall with VLE usage, though not always statistically significant in every dimension measured (Ryan & Poole, 2019).

Findings from hypothesis three showed that the use of Automated Scoring Systems significantly impacts students' learning outcomes in secondary schools within Education District IV of Lagos State. The findings of this study suggest a generally positive influence of automated scoring and feedback technologies on learning outcomes, particularly through the provision of timely feedback, increased engagement, and improved revision behaviour. This aligns with existing research evidence that automated assessment technologies can enhance students' performance by delivering immediate, consistent feedback that supports rapid learning adjustments. This finding is consistent with Elmoon Akhter and Uz Zaman (2024), who conducted a meta-review of Automated Essay Scoring (AES) and Automated Writing Evaluation (AWE) systems. Their synthesis of multiple studies showed that automated scoring technologies produced significant improvements in writing quality, grammar accuracy, and lexical sophistication, demonstrating moderate pedagogical impact across diverse learner groups.

Additionally, evidence from Langove & Khan (2024) indicates that automated scoring and feedback systems reduce the time between assignment submission and feedback, which is a key factor in supporting effective learning. Studies report enhanced student interaction, increased assignment completion rates, and higher participation following the introduction of automated feedback systems, suggesting that efficiency and immediacy of feedback contribute to better learning outcomes. Fleckenstein, Liebenow, and Meyer (2023) reported that automated feedback interventions positively influence students' performance outcomes in writing tasks, highlighting the educational benefits of integrating automated scoring within formative assessment practices. This finding aligns with Hahn, Baldiris Navarro, De La Fuente and Burgos (2021), who conducted a systematic review of 125 studies published between 2016 and 2020 on the use of automatic scoring and feedback in educational settings. Their study demonstrated that automated scoring systems improve student learning experiences by reducing the time between assignment submission and feedback, minimizing bias in scoring, and enabling scalability without increasing the number of instructors. These benefits contribute to better learning outcomes by allowing students to receive prompt, objective, and consistent evaluations of their work.

Findings from hypothesis four revealed that adaptive learning systems significantly impact students' learning outcomes in secondary schools within Education District IV of Lagos State. The findings of this study suggest that adaptive learning systems, through personalized content delivery, tailored pacing, and individualized feedback, can enhance academic performance and learner engagement, supporting their positive influence on learning outcomes. This result aligns with du Plooy, Casteleijn & Franzsen (2024) indicating that adaptive learning systems personalize instruction to meet individual learner needs, which often leads to improved academic performance and engagement. A scoping review of personalized adaptive learning found that a majority of studies reported enhanced academic performance and learning outcomes when adaptive systems were implemented, as these systems adjust content and pacing to individual learners' profiles and provide tailored support.

In addition, du Plooy, Casteleijn & Franzsen (2024) suggest that adaptive instructional environments are associated with improved student achievement and increased engagement by continuously adjusting content and feedback in response to learner performance. These systems help address individual learning gaps and motivate students by aligning tasks with their readiness levels and learning goals. Moreover, Contrino, Reyes-Millán, Vázquez-Villegas & et al. (2024) have shown improvements in learning outcomes when compared to non-adaptive instructional conditions, indicating the effectiveness of adaptive learning in enhancing student performance within structured learning environments.

However, while much evidence underscores the positive effects of adaptive technologies on learner outcomes, some studies suggest that the impact may vary depending on factors such as implementation design, subject area, and integration quality. Nonetheless, the overall trend across peer-reviewed research leans toward adaptive learning systems contributing significantly to students' academic success by delivering personalized instruction, supporting self-paced learning, and enhancing engagement with learning materials.

Findings from hypothesis five revealed that the integration of Intelligent Tutoring Systems (ITS), Adaptive Learning Systems (ALS), Virtual Learning Environments (VLEs), and Automated Scoring Systems (ASS) would significantly improve students' learning outcomes in secondary schools within Education District IV of Lagos State. The results of this study indicate that when these four educational technologies are combined or implemented synergistically, students demonstrate enhancement in academic understanding, engagement, motivation, and performance outcomes. This finding is supported by multiple strands of empirical research. For instance, Akyuz (2020) and Al-Aqbi, Saedi, and Saleh (2019) found that ITS enhances personalized

learning and contributes to improved student performance, especially when tailored feedback and adaptive pacing are provided.

Likewise, Ilić, Ivanovic, and Milicevic (2024) reported that ITS integration with AI significantly influences motivation and achievement, indicating that ITS functions optimally when connected with broader adaptive instructional ecosystems. Additionally, the positive influence of Virtual Learning Environments on academic engagement and learning outcomes has been documented. Ademola (2021) reported that VLE satisfaction correlates with academic performance, and Barker and Gossman (2013) confirmed that the use of a VLE enhances learners' motivation and learning effectiveness. These studies affirm that VLEs, especially when integrated with other technologies such as adaptive systems, contribute to richer and more effective learning experiences.

The role of Adaptive Learning Systems is similarly affirmed by research showing their capacity to customize instruction and pace to individual learners' needs. For instance, du Plooy, Casteleijn, and Franzsen (2024) conducted a scoping review that linked personalized adaptive learning with improved academic outcomes and student engagement. Contrino et al. (2024) further found that adaptive learning tools improve performance and satisfaction in both online and face-to-face contexts, highlighting their flexibility and impact across learning environments. Automated feedback and scoring systems also constitute a key component of integrated learning technologies.

Hahn, Baldiris Navarro, De La Fuente Valentín, and Burgos (2021) concluded that automated scoring and feedback mechanisms accelerate learning by reducing the time between submission and evaluation, providing consistent, unbiased support, and enhancing revision practices. Langove and Khan (2024) likewise established that automated grading systems improve student performance, reinforcing the value of these systems within integrated technological frameworks. Taken together, these studies suggest that implementing ITS, ALS, VLEs, and ASS in a coordinated manner provides complementary benefits that enhance students' learning outcomes more than any single technology in isolation. The integration facilitates personalized instruction, timely and objective feedback, student engagement and motivation, and self-regulated learning, leading to significant improvements in academic performance.

Conclusion

Based on the research findings, it was concluded that Intelligent Tutoring Systems (ITS), Adaptive Learning Systems (ALS), Virtual Learning Environments (VLEs), and

Automated Scoring Systems (ASS) each significantly enhance students' learning outcomes in secondary schools within Education District IV of Lagos State.

Recommendations

Given the findings of this study, the following recommendations were made:

1. Secondary schools in Education District IV should adopt and expand the use of Intelligent Tutoring Systems across core subjects such as Mathematics, Science, and English.
2. Schools should strengthen the use of VLE platforms such as Moodle or Google Classroom for lesson delivery, assignments, and communication.
3. Schools should adopt Automated Scoring and Feedback Systems to enhance the speed, consistency, and quality of student assessment. These systems should be used particularly for formative assessments such as quizzes, essays, and practice tests, where timely feedback is essential for learning improvement.
4. Education policymakers and school administrators should promote the implementation of Adaptive Learning Systems that tailor content, pacing, and feedback to individual learner needs. These systems should be used to support students with different learning abilities by identifying knowledge gaps and providing targeted instructional support.
5. The Lagos State Ministry of Education should develop a comprehensive digital learning framework that encourages the integrated use of ITS, Adaptive Learning Systems, Virtual Learning Environments, and Automated Scoring Systems.

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