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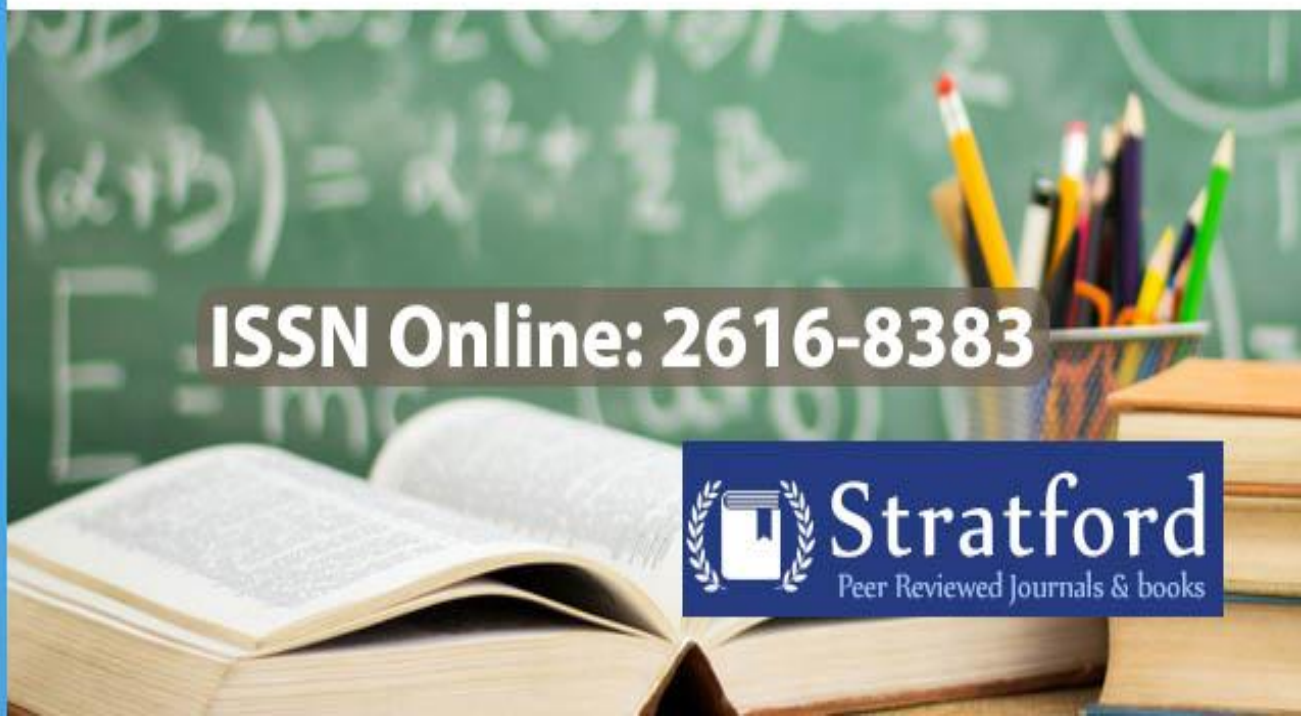

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Abstract

This study examined the effect of artificial intelligence (AI) usage on academic achievement among university students in Kenya, with a particular focus on the moderating role of AI literacy. The study was guided by the Diffusion of Innovations (DOI) Theory and Social Cognitive Theory (SCT) and anchored on the positivist research philosophy. The target population comprised 89,391 third- and fourth-year undergraduate students from 11 universities in Nairobi County, from which a sample of 398 respondents was selected using proportionate stratified sampling. Primary data were collected using structured self-administered questionnaires. Findings from Hayes' PROCESS Macro Model 1 revealed that AI usage significantly influenced academic achievement and that AI literacy significantly moderated the relationship between AI usage and academic achievement, such that students with higher levels of AI literacy derived greater academic benefits from AI tools than those with lower levels of AI literacy. The study concludes that the academic benefits of AI usage are enhanced when students possess adequate AI literacy to effectively and responsibly utilize AI technologies. The study recommends that universities should promote AI literacy and responsible AI usage through training and support programs to maximize students' academic achievement.

Keywords: *Artificial Intelligence, Higher Education, AI usage, Academic Achievement, AI literacy*

1. Introduction

Academic achievement remains a critical determinant of human capital development and economic growth, even in the era of Artificial Intelligence (AI). While AI is transforming industries and automating routine tasks, educational attainment continues to be essential for enabling individuals to effectively utilize emerging technologies and drive innovation. Research

shows that improvements in student learning outcomes are strongly associated with economic growth, with a one-standard-deviation increase in learning linked to approximately $400 growth in GDP per capita (Educational Research Institute, 2025). Furthermore, generative AI is projected to contribute between $61 and $103 billion to Africa's economy, but the realization of this potential depends heavily on the availability of educated and AI-literate graduates (Ekdahl, 2025). Consequently, enhancing academic achievement among university students remains fundamental to strengthening Africa's competitiveness and supporting sustainable development in the digital age.

The increasing adoption of AI tools in higher education has generated considerable interest regarding their influence on students' academic performance. AI-powered applications assist learners in searching for information, understanding complex concepts, and receiving immediate feedback, thereby improving learning efficiency and effectiveness (Neji et al., 2023). Studies have demonstrated that AI-supported learning environments can enhance students' engagement, organization of academic tasks, writing abilities, research skills, and problem-solving capacities, leading to improved academic outcomes (Bai et al., 2022; Kasneci et al., 2023; Chen et al., 2023). However, concerns have also emerged regarding excessive dependence on AI tools. Scholars argue that overreliance on AI-generated outputs may weaken critical thinking, analytical abilities, and deep learning by encouraging surface-level engagement with academic content (Rudolph et al., 2023; Baidoo-Anu & Owusu Ansah, 2023; Perkins, 2024). Additionally, the growing use of AI raises concerns about academic integrity, as AI-generated content may blur the distinction between legitimate academic assistance and academic misconduct (Cotton et al., 2024).

Beyond its direct impact on academic achievement, AI usage has been associated with students' academic self-efficacy, which refers to learners' confidence in their ability to successfully complete academic tasks. Academic self-efficacy is widely recognized as a significant predictor of motivation, persistence, and academic success (Schunk & DiBenedetto, 2025). AI tools can strengthen self-efficacy by providing personalized support, timely feedback, and accessible explanations that help students navigate academic challenges more effectively (Kasneci et al., 2023; Zhai & Li, 2025). Empirical evidence suggests that AI-assisted learning environments enhance students' confidence, competence, and efficiency in completing academic tasks such as writing, research, and problem-solving (Chen et al., 2023; Hmoud et al., 2024). Nevertheless, excessive dependence on AI may result in inflated confidence that is not supported by genuine understanding, thereby limiting opportunities for independent learning and critical thinking (Baidoo-Anu & Owusu Ansah, 2023; Zhai et al., 2024). Therefore, balanced and responsible AI usage is necessary to ensure that AI serves as a learning support tool rather than a substitute for student effort and cognitive engagement (Jeilani & Abubakar, 2025).

As AI adoption continues to expand in higher education, AI literacy has emerged as an important factor influencing how students benefit from AI technologies. AI literacy encompasses the knowledge and skills required to understand AI systems, recognize their capabilities and limitations, and apply them ethically and effectively in academic contexts (Chiu et al., 2024). Research indicates that students with higher levels of AI literacy are better able to use AI as a cognitive support tool rather than as a replacement for independent thinking (Long et al., 2022; Zhai, 2024). Studies further show that training in AI usage enhances creativity, problem-solving abilities, self-efficacy, and academic performance, whereas unguided AI use may discourage originality and promote dependency (Du et al., 2025; Amiruddin et al., 2025; Bosarge, 2025;

Perkins, 2024). This issue is particularly relevant in Africa and Kenya, where AI adoption among students is increasing rapidly. Kenya ranks among the leading countries globally in ChatGPT usage, highlighting the growing integration of AI into learning processes (North Africa Post, 2025). However, concerns regarding academic integrity, overreliance on AI, and inadequate digital skills persist (Prothero, 2024; Owino, 2025). These developments underscore the need to examine how AI usage influences academic achievement and whether AI literacy strengthens or weakens this relationship among university students in Kenya.

2. Theoretical Review

The study is anchored on the Diffusion of Innovations (DOI) Theory developed by Rogers (1962) and the Social Cognitive Theory (SCT) proposed by Bandura (1986). DOI Theory explains how new ideas, technologies, and innovations spread through a social system over time, emphasizing that adoption occurs through a process involving knowledge, persuasion, decision, implementation, and confirmation (García-Avilés, 2020; Vejlgaard, 2018). The theory has been extensively applied in educational technology research to explain the adoption and utilization of innovative learning tools, where factors such as relative advantage, compatibility, complexity, trialability, and observability influence acceptance and usage (Frei-Landau et al., 2022). In the context of this study, AI literacy is viewed as an educational innovation whose diffusion among university students determines how effectively AI tools are adopted and integrated into learning activities. Students with higher levels of AI literacy are expected to understand AI tools better, appreciate their benefits, and use them more effectively to support learning, thereby enhancing academic achievement. Complementing DOI, Social Cognitive Theory provides an explanation of the cognitive and motivational mechanisms through which AI literacy influences academic outcomes. SCT posits that learning and behavior are shaped through the reciprocal interaction of personal factors, behavior, and environmental influences, with self-efficacy serving as a central determinant of individual performance (Lopez-Garrido, 2023). Research has consistently demonstrated that students with higher self-efficacy are more likely to engage with technology, adopt effective learning strategies, persist in challenging tasks, and achieve better academic outcomes (Miao et al., 2025). Within this study, AI literacy is expected to enhance students' confidence in using AI technologies for academic purposes, enabling them to utilize AI responsibly and effectively while maintaining active engagement in learning processes. Consequently, the integration of DOI and SCT provides a comprehensive framework for understanding how AI literacy facilitates the adoption and effective use of AI tools and how such usage ultimately influences academic achievement among university students in Kenya.

3. Empirical Review (Hypothesis Development)

Several empirical studies indicate that the use of artificial intelligence technologies for learning tasks is associated with improved academic outcomes among university students. For instance, Khan, et al., (2025) found that the use of AI tools such as ChatGPT, Grammarly, and Google Bard had a significant positive effect on undergraduate students' academic performance, particularly in writing assignments, research activities, and examination preparation. Their findings revealed that students who frequently used AI tools performed better academically than those with lower levels of usage. Similarly, a large-scale study by Pacheco-Mendoza et al., (2023), involving 1,843 university students in Pakistan, demonstrated that AI-driven systems significantly supported academic achievement by identifying individual learning needs and providing timely academic interventions that enhanced performance outcomes. In addition, a smaller quantitative study by

Ma'amor et al., (2024) conducted among undergraduates at UiTM Puncak Alam Campus reported that AI usage for study purposes had a significant influence on academic performance, with regression results showing that higher levels of AI use explained a meaningful proportion of variance in academic outcomes. Collectively, these findings support the view that increased engagement with AI tools can enhance university students' academic achievement.

Beyond objective performance measures, research also shows positive associations between AI usage and students' perceptions of their academic success. Ajakaiye et al., (2025), in a study among undergraduates in Kwara State, found a positive correlation between the use of AI tools such as QuillBot and ChatGPT and perceived academic achievement, suggesting that students who regularly rely on AI for academic tasks tend to report better learning outcomes. Consistent with this, broader surveys by Vieriu and Petrea (2025) on AI adoption in higher education revealed widespread integration of AI tools into students' academic routines, with frequent use for homework, research, and writing tasks—practices that many students associate with improved comprehension and academic performance. Although not focused exclusively on test scores, Adewale et al., (2024) observed that the high frequency of AI use in academic tasks reflects students' belief that these technologies improve learning efficiency and outcomes, a perception that correlates with higher engagement levels and improved performance indicators in related analyses.

However, not all empirical evidence points to uniformly positive effects, highlighting the importance of how AI tools are used. For example, Archana et al., (2025) reported that although over 90% of surveyed students used AI for academic activities, differences in usage patterns produced varied outcomes. Some forms of AI use enhanced task efficiency, while others showed mixed effects on deeper learning processes. Similarly, Dai et al., (2025) provided experimental evidence, albeit outside strict university contexts, indicating that certain patterns of AI-generated feedback can produce differential effects on academic achievement, benefiting some students while offering limited or even negative effects for others depending on learning autonomy and usage context. While these findings do not undermine the potential value of AI tools in education, they suggest that the effect of AI usage on academic achievement is contingent on usage type, learning environment, and student characteristics. Consequently, this study hypothesized that:

H_1: *artificial intelligence usage significantly influences academic achievement*

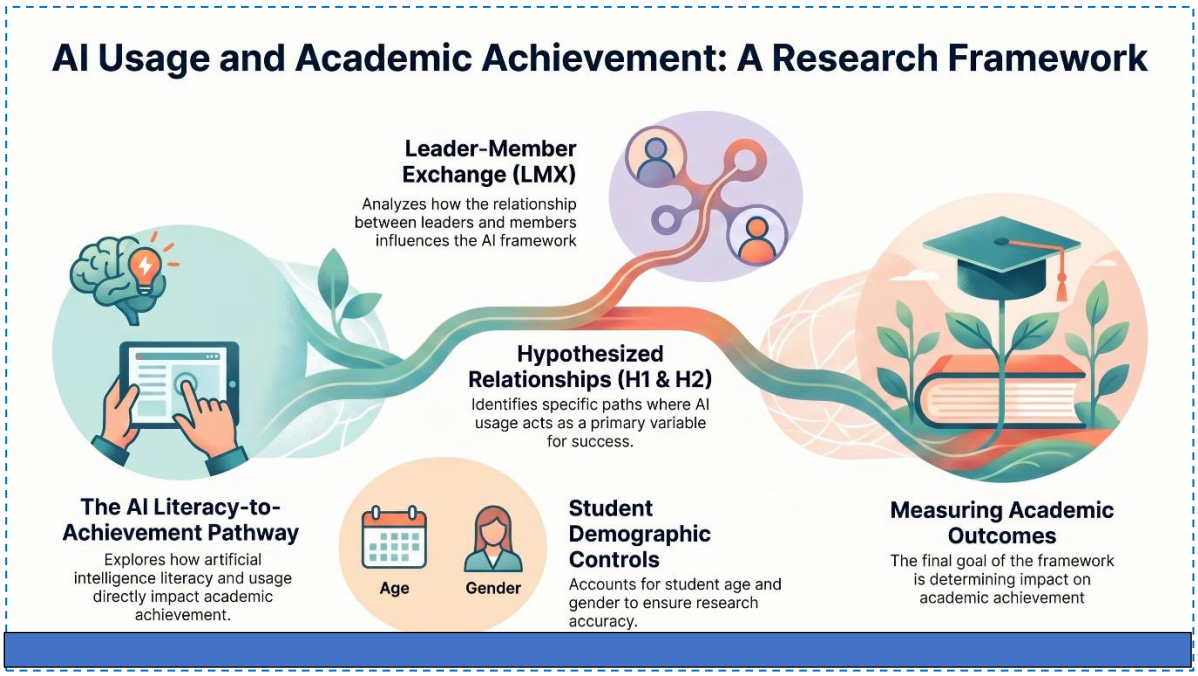
Khan et al. (2025), in a quantitative study involving 200 undergraduate students, found that frequent use of AI tools such as ChatGPT, Grammarly, and Google Bard was positively associated with higher academic achievement, particularly in writing tasks, research activities, and exam preparation. These findings suggest that AI usage can directly support students' academic performance. However, Bećirović, Polz, and Tinkel (2025) demonstrated that students' AI literacy plays a crucial role in determining how effectively these tools are used for learning. While components of AI literacy significantly influenced students' self-efficacy and the quality of AI-generated outputs, they did not directly predict academic achievement, implying that literacy conditions how AI usage translates into academic success rather than exerting a direct effect. Similarly, Lai (2025) reported that AI-supported personalized learning was positively associated with improved academic performance and that this relationship was stronger among students with higher levels of digital competence, indicating a contextual moderating effect of literacy on the AI usage–achievement relationship.

Although direct empirical tests of moderation remain limited, related studies provide further support for the proposition that competence in AI and digital tools enhances the academic benefits derived from AI usage. Bećirović et al. (2025) found that practical AI application and technical understanding significantly increased students' AI self-efficacy, a psychological factor closely linked to academic engagement and learning persistence. This suggests that AI literacy may indirectly strengthen the academic effects of AI usage by fostering higher engagement with learning tasks. Likewise, research on digital and AI technologies indicates that students who possess stronger literacy skills engage more meaningfully with learning activities, resulting in improved comprehension and engagement both of which are important predictors of academic achievement (Bećirović et al., 2025). Evidence from studies of AI-powered personalized learning environments further shows that digital literacy moderates the effectiveness of AI-enhanced instruction on outcomes such as academic performance and motivation, reinforcing the view that literacy shapes the extent to which AI usage benefits learning (Lai, 2025).

Emerging research from closely related domains also sheds light on the mechanisms through which AI literacy may moderate the effects of AI usage on academic achievement. Bećirović et al. (2025) observed that AI literacy significantly influenced students' confidence and the quality of AI-generated outputs, factors that enable learners to apply AI tools more effectively even though a direct link between literacy and academic performance was not established, highlighting the complexity of these relationships. Similarly, Shi et al. (2025) found that students with higher AI competencies were better able to leverage AI feedback and adaptive resources, thereby supporting deeper learning and improved performance, albeit measured indirectly. Studies on AI-driven personalized learning further demonstrate that digital literacy strengthens the positive effects of adaptive AI tools on academic engagement and learning outcomes, underscoring literacy as a critical boundary condition for AI usage benefits. Taken together, although direct moderation analyses are still emerging (Lai, 2025), the existing empirical evidence strongly suggests that AI literacy amplifies the positive influence of AI usage on academic achievement by enabling students to interpret, apply, and benefit from AI resources more effectively. Based on the reviewed literature, the study hypothesized that.

$H_{6:}$ *Artificial intelligence literacy moderates the relationship between artificial intelligence usage and academic achievement.*

Independent Variable **Moderating Variable** **Dependent Variable**



Source: Author (2026)

4. Methodology

This study was anchored on the positivist research philosophy, which assumes that reality is objective and can be measured using observable and quantifiable indicators. Positivism is appropriate where hypotheses are tested through statistical techniques to establish relationships among variables. The philosophy was suitable for this study since it focused on examining the direct, mediating, moderating, and moderated mediation effects of Artificial Intelligence (AI) usage and Artificial Intelligence literacy on students' academic achievement, with students' self-efficacy serving as an intervening variable. The study adopted an explanatory cross-sectional survey research design. This design was appropriate because it enables the examination of cause–effect relationships among variables within a single point in time. The design allowed for the collection of quantitative data required to test hypotheses concerning the influence of AI usage and AI literacy on academic achievement and the role of self-efficacy in these relationships.

Target Population and Sampling

The study targeted 89,391 third and fourth year undergraduate students drawn from 11 universities (4 public and 7 private) in Nairobi County. From this population, a sample was determined using Slovin's formula as developed by Yamane (1967), adopting a 5% margin of error, which falls within the acceptable range for social and educational research (Story & Tait, 2019). This resulted in a sample size of 398 respondents, which was considered adequate for robust quantitative analysis. The study employed proportionate stratified sampling, with universities treated as strata

to ensure fair representation across institutional types. Thereafter, simple random sampling was applied within each stratum to select individual respondents. Out of the 398 questionnaires administered, 322 were successfully returned, representing a response rate of 80.9 percent. Following data screening and cleaning, 13 questionnaires were excluded, of which 8 contained significant outliers and 5 had substantial missing values. This resulted in 307 usable questionnaires, translating to a valid response rate of 77.1 percent of the total sample, which is considered satisfactory for quantitative analysis.

Data Collection, Validity, and Reliability

Primary data were collected using a structured self-administered questionnaire. The questionnaire consisted of sections measuring Artificial Intelligence usage, Artificial Intelligence literacy, students' self-efficacy, and academic achievement. Academic achievement was measured using the Academic Achievement Questionnaire (AAQ), which captures students' perceived academic performance across assessment, learning outcomes, and task completion dimensions. The use of a questionnaire was appropriate as it facilitated the collection of standardized data from a large number of respondents efficiently. Validity of the research instrument was ensured through content and construct validity. Content validity was achieved by consulting experts in educational technology and research methodology, while construct validity was assessed using factor analysis. Reliability was tested using Cronbach's alpha coefficient, with values of 0.70 and above considered acceptable, indicating internal consistency of the measurement scales.

Artificial Intelligence Usage was measured using items adapted from prior studies examining students' engagement with AI-based learning tools, including intelligent tutoring systems, generative AI applications, and AI-supported academic platforms (Kumar et al., 2021; Zhai et al., 2021). The scale assessed frequency, purpose, and intensity of AI use in academic activities, with higher scores indicating greater AI usage.

Artificial Intelligence Literacy was measured using a multidimensional scale capturing students' understanding of AI concepts, ability to use AI tools effectively, and awareness of ethical and academic integrity issues related to AI use (Long & Magerko, 2020; Ng et al., 2021). The scale reflected students' capacity to critically and responsibly engage with AI technologies in learning environments.

Academic achievement was measured using the Academic Achievement Questionnaire (AAQ)**,** a validated self-report instrument designed to capture students' perceived academic performance across assessment outcomes, learning effectiveness, and task completion (Richardson et al., 2012; York et al., 2015). The AAQ has been widely used in higher education research and has demonstrated acceptable reliability and construct validity.

Data Analysis and Model Specification

Following data preparation, the study employed both descriptive and inferential statistical analyses. Descriptive statistics, including frequencies, means, standard deviations, skewness, and kurtosis, were used to summarize the data and assess its distributional characteristics. Correlation analysis was conducted to examine the strength and direction of relationships among the study

variables and to assess the possibility of multicollinearity. To test the direct effects of AI usage on academic achievement and the moderating effect of AI literacy, Hayes' PROCESS Macro Model 1 was employed. Prior to the regression analysis, several diagnostic tests were conducted, including tests for normality, linearity, autocorrelation, multicollinearity, and homoscedasticity, to ensure that the assumptions underlying regression analysis were satisfied. The significance of the moderation effects was assessed using bootstrapping procedures with 5,000 resamples, as recommended by Hayes (2018), which generated bias-corrected confidence intervals for more robust statistical inference.

5. Findings

Table 1 presents the demographic characteristics of the respondents based on gender and age bracket among university students in Kenya. The findings indicate that female students constituted 59% of the respondents while male students accounted for 41%, showing that female students formed the majority of the sample. In terms of age distribution, most students (73%) were aged between 21 and 30 years, followed by 22.8% aged 20 years and below, while only a small proportion were aged between 31 and 40 years (2.6%) and 41 and 50 years (1.6%)

Table 1 Students' Characteristics

		Frequency	Percent
Gender	Male	126	41
	Female	181	59
	Total	307	100
Age Bracket	20 years and below	70	22.8
	21- 30 yrs	224	73
	31- 40 yrs	8	2.6
	41-50 yrs	5	1.6
	Total	307	100

Descriptive Statistics

Table 2 presents the descriptive statistics on artificial intelligence (AI) usage among university students in Kenya. The findings show that the overall mean score for AI usage was 3.54 (SD = 0.84), indicating a relatively high level of AI usage among students in their academic activities. The highest usage was reported in using AI to explain difficult academic concepts (M = 4.08, SD = 0.95), followed by using AI to search for academic information and research materials (M = 3.89, SD = 1.00) and compare information from different sources (M = 3.89, SD = 1.01), suggesting that students primarily rely on AI as a learning support and research tool. Similarly, students frequently used AI to generate practice questions (M = 3.84, SD = 1.04), check accuracy of information (M = 3.82, SD = 1.12), and complete class assignments (M = 3.73, SD = 1.07), highlighting the important role of AI in enhancing understanding, academic preparation, and assignment completion. However, relatively lower usage was reported in using AI for translation (M = 3.06, SD = 1.46), designing posters or visual content (M = 3.11, SD = 1.34), and writing essays or reports (M = 3.13, SD = 1.31), suggesting that students were comparatively less reliant on AI for creative and language-related tasks. The moderate standard deviations across the items

indicate some variability in students' AI usage, but overall, the findings demonstrate that AI has become an important academic support tool that enhances students' learning processes, research activities, and academic performance.

Table 2 AI usage

n=307	Mean	Std. Dev
I use AI tools to complete my class assignments.	3.73	1.07
I use AI to write essays, reports, or term papers.	3.13	1.31
I use AI to help write my research project/thesis.	3.71	1.16
I use AI to edit grammar and improve writing quality.	3.49	1.41
I use AI to paraphrase or rephrase content.	3.33	1.39
I use AI to summarize long texts or articles.	3.55	1.26
I use AI to outline or structure my academic work.	3.45	1.43
I use AI to proofread my assignments before submission.	3.16	1.43
I use AI to generate citations or reference lists APA format	3.19	1.35
I use AI to explain difficult academic concepts.	4.08	0.95
I use AI to prepare for examinations.	3.63	1.27
I use AI to revise lecture content.	3.50	1.39
I use AI to receive feedback on my answers.	3.55	1.29
I use AI to generate practice questions or quizzes.	3.84	1.04
I use AI to improve my study habits and strategies.	3.66	1.26
I use AI to access visual learning aids (videos, diagrams, charts).	3.38	1.26
I use AI to explore topics beyond what is taught in class.	3.71	1.24
I use AI to search for academic information/research materials/	3.89	1.00
I use AI to check the accuracy of information I find online.	3.82	1.12
I use AI to compare information from different sources.	3.89	1.01
I use AI to generate research ideas or problem statements.	3.78	0.97
I use AI to create class presentations or slides.	3.25	1.22
I use AI to design posters or visual content for school projects.	3.11	1.34
I use AI-powered translation tools to communicate in different languages.	3.06	1.46
AI usage	**3.54**	**0.84**

Table 3 presents the descriptive statistics on artificial intelligence (AI) literacy among university students in Kenya. The findings indicate that the overall mean score for AI literacy was 3.98 (SD = 0.62), suggesting a high level of AI literacy among the students. The highest level of agreement was observed in students' understanding of what AI is (M = 4.26, SD = 0.74) and their knowledge of how AI can support learning and daily tasks (M = 4.24, SD = 0.84), indicating strong foundational awareness and practical understanding of AI applications. Students also reported high ability to remain cautious when using AI content (M = 4.17, SD = 0.82) and familiarity with AI concepts (M = 4.16, SD = 0.87), suggesting that most students are knowledgeable and responsible users of AI technologies. However, relatively lower mean scores were observed in more technical aspects such as understanding differences between deep learning and machine learning (M = 3.70, SD = 0.98) and understanding legal issues related to AI use (M = 3.75, SD = 0.93), indicating

comparatively lower competence in advanced and regulatory aspects of AI. Overall, the low standard deviation and high mean scores indicate that most students possess adequate knowledge, skills, and ethical awareness required to effectively and responsibly use AI tools to support their academic learning and performance.

Table 3 AI literacy

n=307	Mean	Std. Dev
I understand what artificial intelligence is.	4.26	0.74
I am familiar with basic ideas and concepts related to artificial intelligence.	4.16	0.87
I understand how AI interacts with the world (e.g., speaking, hearing, recognizing images).	4.14	0.88
I can tell the difference between smart devices and non-smart devices.	4.16	0.91
I can explain basic differences between deep learning and machine learning.	3.70	0.98
I know how artificial intelligence can support my learning and daily tasks.	4.24	0.84
I can name different AI tools or applications.	3.82	1.00
I can choose the most suitable AI tool for a specific task	3.82	0.91
I can select the best solution from AI recommendations.	4.06	0.84
I check the accuracy of AI-generated content when unsure.	4.04	0.78
I know how to verify whether AI information is trustworthy.	3.82	0.91
I can assess the limitations of different AI tools.	3.76	0.88
I can recognize bias or errors in AI-generated content.	3.87	0.98
I remain cautious when using content from AI.	4.17	0.82
I follow ethical guidelines when using AI tools.	3.87	0.95
I understand basic legal issues related to using AI.	3.75	0.93
I am aware of privacy and data security concerns when using AI.	3.96	0.90
I think about how AI impacts people and society.	3.93	0.89
I use AI responsibly and ethically.	4.03	0.87
AI literacy	**3.98**	**0.62**

Assumptions

Regression analysis was used to examine the relationship between artificial intelligence usage, artificial intelligence literacy, academic self-efficacy, and academic achievement, and diagnostic tests were conducted to ensure that the assumptions of regression were satisfied. The normality test using the Shapiro–Wilk statistic showed a non-significant p-value of 0.152, indicating that the residuals were normally distributed. The linearity test results were significant ($p = 0.000$) for all relationships, confirming the existence of linear relationships between academic achievement and AI usage and AI literacy. The Durbin–Watson statistics ranged from 1.449 to 1.668, indicating no autocorrelation among residuals. The multicollinearity test showed tolerance values above 0.1 (0.593–0.986) and VIF values below 10 (1.014–1.687), confirming the absence of multicollinearity among predictor variables. Additionally, the homoscedasticity test using Levene's test produced non-significant p-values ($p = 0.623–0.778$), indicating equal variance of

residuals. Overall, these results confirm that all regression assumptions were satisfied, making the data suitable for regression analysis and hypothesis testing

Correlation Analysis

The correlation analysis results presented in Table 4 show the relationship between academic achievement, AI usage, AI literacy, gender, and age bracket. The findings indicate that AI usage had a positive and significant relationship with academic achievement ($r = .342$, $p < .01$), implying that increased use of AI tools was associated with higher academic achievement among students. Similarly, AI literacy showed a moderate positive and significant relationship with academic achievement ($r = .486$, $p < .01$), suggesting that students with higher levels of AI literacy tended to perform better academically. the results demonstrate that AI usage, AI literacy, and academic self-efficacy are important factors associated with academic achievement.

Table 4 Academic Self-Efficacy

	Student achievement	AI usage	AI literacy	Gender	Age
Student achievement	1				
AI usage	.342**	1			
AI literacy	.486**	.638**	1		
Gender	-0.098	.145*	.169**	1	.131*
Age	.133*	.206**	0.103	.131*	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Hypotheses Testing

This study examined whether AI literacy moderates the relationship between AI usage and students' self-efficacy. The moderation analysis was conducted using Hayes' PROCESS Model 1, which tests whether the strength or direction of the relationship between an independent variable (AI usage) and a dependent variable (self-efficacy) changes depending on the level of a moderator (AI literacy), while controlling for covariates (q1 and q2). The overall model was statistically significant ($R^2 = 0.303$, $F = 26.198$, $p = 0.000$), indicating that AI usage, AI literacy, their interaction, and the covariates jointly explained 30.3% of the variation in students' self-efficacy.

The results show that AI usage had a statistically significant negative main effect on students' self-efficacy ($\beta = -0.736$, $SE = 0.251$, $t = -2.930$, $p = 0.004$). This finding suggests that when AI literacy is not considered, increased AI usage alone may reduce students' confidence in their academic abilities, possibly due to overreliance on AI tools or lack of sufficient understanding of how to use them effectively. However, AI literacy itself did not have a statistically significant direct effect on self-efficacy ($\beta = -0.211$, $SE = 0.215$, $t = -0.980$, $p = 0.328$), indicating that AI literacy alone does not directly influence students' academic confidence without considering its interaction with AI usage.

Most importantly, the interaction between AI usage and AI literacy was positive and statistically significant (β = 0.188, SE = 0.061, t = 3.086, p = 0.002, LLCI = 0.068, ULCI = 0.308). The significant interaction term and the increase in explained variance ($\Delta R^2 = 0.022$, F change = 9.526, p = 0.002) confirm the presence of a moderation effect. This indicates that AI literacy changes the strength and direction of the relationship between AI usage and students' self-efficacy. Specifically, AI literacy strengthens the positive impact of AI usage on self-efficacy.

Further analysis of the conditional effects at different levels of AI literacy provides deeper insight into the moderation effect. At low levels of AI literacy (16th percentile), AI usage had a negative and statistically significant effect on self-efficacy (β = −0.142, SE = 0.069, p = 0.042), indicating that students with limited AI literacy experience reduced academic confidence when using AI tools. At moderate levels of AI literacy (50th percentile), the effect of AI usage on self-efficacy was positive but not statistically significant (β = 0.027, SE = 0.042, p = 0.521), suggesting that AI usage does not substantially influence self-efficacy among students with average AI literacy. However, at high levels of AI literacy (84th percentile), AI usage had a positive and statistically significant effect on self-efficacy (β = 0.126, SE = 0.053, p = 0.017), indicating that students with strong AI literacy benefit from AI usage by developing greater confidence in their academic abilities.

These findings confirm that artificial intelligence literacy plays a critical moderating role in the relationship between AI usage and students' self-efficacy. Specifically, AI usage enhances students' self-efficacy only when students possess sufficient AI literacy to effectively understand, interpret, and apply AI-generated information. In contrast, students with low AI literacy may experience reduced confidence due to confusion, dependence, or inability to effectively utilize AI tools. Therefore, the positive benefits of AI usage on academic self-efficacy depend on students' level of AI literacy. Based on these findings, Hypothesis H5, which stated that artificial intelligence literacy moderates the relationship between artificial intelligence usage and students' self-efficacy, is supported, and the null hypothesis is rejected.

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Table 5: Hayes Model 1: moderating Effect of Artificial Intelligence Literacy on the Relationship Between Artificial Intelligence Usage and Academic Achievement

Model (Outcome: Academic Achievement)						
	β	**SE**	**t**	**p**	**LLCI**	**ULCI**
Constant	4.774	0.826	5.778	0.000	3.148	6.400
AI Usage	−0.736	0.251	−2.930	0.004	−1.231	−0.242
AI Literacy	−0.211	0.215	−0.980	0.328	−0.635	0.213
AI Usage × AI Literacy	0.188	0.061	3.086	0.002	0.068	0.308
Students age	−0.150	0.06	−2.480	0.014	−0.269	−0.031
Student gender	0.074	0.052	1.423	0.156	−0.028	0.176
Summary Statistics						
R	0.551					
R^2	0.303					
F-statistic	26.198					
p-value	0.000					
R^2 Change (Interaction)	0.022					
F Change	9.526					
p (Interaction)	0.002					
AI Literacy Level	**Effect**	**SE**	**t**	**p**	**LLCI**	**ULCI**
Low (16th percentile)	−0.142	0.069	−2.045	0.042	−0.278	−0.005
Medium (50th percentile)	0.027	0.042	0.643	0.521	−0.056	0.110
High (84th percentile)	0.126	0.053	2.400	0.017	0.023	0.230

6. Discussion of the Findings

The findings of this study revealed that artificial intelligence (AI) literacy significantly moderates the relationship between AI usage and students' academic achievement. The moderation analysis using Hayes' PROCESS Model 1 showed that the interaction between AI usage and AI literacy was positive and statistically significant indicating that the effect of AI usage on academic achievement depends on students' level of AI literacy. Although AI usage exhibited a negative direct effect on academic achievement when AI literacy was not considered the positive interaction term suggests that students who possess higher levels of AI literacy are able to derive greater academic benefits from AI tools. Therefore, the findings demonstrate that AI literacy acts as a critical boundary condition that determines whether AI usage contributes positively or negatively to students' academic outcomes.

The conditional effects analysis provides further support for this conclusion. At low levels of AI literacy, AI usage had a significant negative effect on academic achievement indicating that students who lack adequate AI literacy may struggle to benefit from AI technologies. This finding suggests that students with limited understanding of AI tools may misuse AI-generated information, become overly dependent on automated responses, or fail to critically evaluate AI outputs, resulting in poorer academic outcomes. However, at average levels of AI literacy, the effect of AI usage on academic achievement became positive but statistically insignificant suggesting that moderate AI literacy helps neutralize the negative effects of AI use but may not be sufficient to generate substantial academic gains. Most importantly, at high levels of AI literacy,

AI usage exerted a significant positive effect on academic achievement This indicates that students who possess strong AI literacy skills are better equipped to effectively utilize AI technologies for learning, enabling them to enhance their academic performance through improved access to information, personalized learning support, and efficient completion of academic tasks. These findings are consistent with the study by Khan et al. (2025), who reported that students who frequently used AI tools such as ChatGPT, Grammarly, and Google Bard achieved better academic outcomes in writing assignments, research activities, and examination preparation. While Khan et al. (2025) established the positive contribution of AI usage to academic performance, the current study extends this understanding by demonstrating that such benefits are not automatic but depend significantly on students' AI literacy levels. The findings also support those of Lai (2025), who found that the positive influence of AI-supported personalized learning on academic performance was stronger among students with higher levels of digital competence. Similar to the present study, Lai (2025) concluded that literacy-related competencies enhance students' ability to maximize the educational benefits of AI technologies. Therefore, the current findings reinforce the argument that AI literacy strengthens the effectiveness of AI usage in academic settings.

The results further align with the findings of Bećirović, Polz, and Tinkel (2025), who observed that AI literacy significantly influenced students' AI self-efficacy and the quality of AI-generated outputs, even though a direct relationship between AI literacy and academic achievement was not established. Similarly, the present study found that AI literacy alone did not have a statistically significant direct effect on academic achievement ($\beta = -0.211$, $p = 0.328$). However, its significant interaction with AI usage demonstrates that AI literacy functions primarily as an enabling factor rather than a direct predictor of academic success. This implies that AI literacy creates the conditions under which students can effectively interpret, evaluate, and apply AI-generated information to academic tasks. Consequently, AI literacy enhances the educational value of AI usage by improving students' ability to engage critically with AI outputs and integrate them meaningfully into their learning processes. The findings are also supported by Shi et al. (2025), who found that students with higher AI competencies were better able to utilize AI feedback and adaptive learning resources to support deeper learning and improved academic outcomes. Likewise, studies on AI-powered personalized learning environments have consistently shown that students with stronger digital and AI-related skills derive greater benefits from AI-supported educational technologies than their less literate counterparts. The current findings suggest that students with high AI literacy are more capable of distinguishing between accurate and inaccurate AI-generated information, adapting AI recommendations to specific learning needs, and maintaining active cognitive engagement during learning. In contrast, students with limited AI literacy may use AI passively, accept AI outputs without critical evaluation, and become dependent on AI-generated solutions, thereby reducing opportunities for meaningful learning and academic growth.

From a theoretical perspective, these findings provide support for both the Diffusion of Innovations Theory (Rogers, 1962) and Social Cognitive Theory (Bandura, 1986). The Diffusion of Innovations Theory suggests that the successful adoption of technological innovations depends on users' knowledge and understanding of the innovation. In this study, AI literacy represents the knowledge component that enables students to effectively adopt and utilize AI technologies for academic purposes. Students with higher AI literacy are more likely to recognize the relative advantages of AI tools and integrate them effectively into their learning activities. Similarly, Social

Cognitive Theory emphasizes that knowledge and competencies influence individuals' behaviors and outcomes. Students who possess strong AI literacy are more likely to use AI confidently, strategically, and responsibly, thereby achieving superior academic outcomes. Thus, the findings demonstrate that AI literacy serves as a critical mechanism through which AI usage translates into improved academic achievement. The results confirm that the academic benefits of AI usage are contingent upon students' AI literacy levels. While AI tools have the potential to enhance learning and academic performance, these benefits are realized only when students possess the necessary knowledge and skills to use AI effectively and responsibly. Students with low AI literacy may experience negative academic consequences arising from overreliance, misuse, or poor interpretation of AI-generated information, whereas students with high AI literacy are able to leverage AI as a learning support tool that enhances academic achievement. Consequently, the findings support Hypothesis H2, which proposed that artificial intelligence literacy moderates the relationship between artificial intelligence usage and academic achievement. The null hypothesis is therefore rejected, and it is concluded that AI literacy significantly strengthens the positive influence of AI usage on academic achievement among university student.

7. Conclusions

The study concluded that artificial intelligence usage significantly influences academic achievement among university students; however, the direction and magnitude of this influence depend on students' levels of AI literacy. While AI usage alone was associated with lower academic achievement, the findings revealed that students who possessed higher levels of AI literacy were able to utilize AI tools more effectively and derive meaningful academic benefits from them. This suggests that the academic value of AI technologies is not determined solely by access or frequency of use, but rather by students' ability to understand, evaluate, and appropriately apply AI-generated information in academic tasks.

The study further concluded that AI literacy is a critical moderating factor in the relationship between AI usage and academic achievement. Students with low levels of AI literacy experienced negative academic effects from AI usage, possibly due to overdependence, misuse of AI-generated content, or inability to critically assess AI outputs. Conversely, students with high AI literacy demonstrated positive academic outcomes from AI usage, indicating that AI literacy enhances students' capacity to integrate AI tools into learning processes effectively. Therefore, AI literacy serves as an important enabling mechanism that transforms AI from a potential academic risk into a valuable educational resource. From a theoretical perspective, the findings support the propositions of Diffusion of Innovations Theory and Social Cognitive Theory by demonstrating that successful adoption and utilization of AI technologies depend on users' knowledge, competencies, and ability to apply innovations effectively. The study therefore concludes that efforts aimed at improving students' academic achievement through AI should prioritize the development of AI literacy alongside increased access to AI technologies

8. Recommendations

Universities should integrate AI literacy training into their curricula to ensure that students develop the knowledge and skills necessary to use AI technologies responsibly, ethically, and effectively. Such training should focus on understanding AI capabilities and limitations, evaluating the

accuracy of AI-generated information, avoiding academic misconduct, and applying AI tools to support critical thinking, problem-solving, and independent learning. By strengthening AI literacy, institutions can maximize the academic benefits of AI while minimizing the risks associated with overreliance and misuse. University administrators and policymakers should develop clear institutional guidelines governing the use of AI in academic activities. These guidelines should provide direction on acceptable and unacceptable uses of AI, promote academic integrity, and encourage students to use AI as a learning support tool rather than a substitute for personal effort. Additionally, universities should establish awareness programs, workshops, and continuous professional development initiatives to help both students and lecturers adapt to the rapidly evolving AI landscape in higher education. Educators should adopt teaching approaches that encourage the responsible integration of AI into learning activities. Rather than prohibiting AI usage, instructors should design learning experiences that require students to critically evaluate AI-generated outputs, reflect on AI-assisted solutions, and demonstrate independent understanding of academic concepts. Such approaches will help students develop deeper learning skills while benefiting from the efficiency and support provided by AI technologies.

9. Future Research

Future research should also examine additional mediating and moderating variables that may influence the relationship between AI usage and academic achievement. Variables such as academic self-efficacy, learning motivation, critical thinking skills, digital literacy, creativity, and technology acceptance may provide deeper insights into the mechanisms through which AI influences learning outcomes in higher education. Further studies should be conducted across different academic disciplines, universities, and countries to determine whether the findings are consistent across diverse educational contexts. Comparative studies involving public and private universities, undergraduate and postgraduate students, as well as different cultural and technological environments, would enhance the generalizability of the findings and contribute to the development of context-specific AI integration strategies in higher education.

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