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Digital Learning Competence, AI Literacy, and STEM Achievement: Examining Pre-Service Teachers in Southwest, Nigeria

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Abstract

Digital Learning and Artificial intelligence are central to 21st-century education but require feasible and careful regulations. This study examined the digital learning competence and AI literacy on STEM achievement of pre-service teachers in Southwest, Nigeria. The objectives of this study were to examine the pre-service teachers' level of digital learning competence and AI literacy. Employing a descriptive survey research design, data were collected from 600 pre-service teachers sampled from six universities and colleges of education using a researcher's designed questionnaire. Mean scores and percentages were used to answer research questions while PPMC, multiple regression and independent t-test were used to analysed hypotheses. Findings show a high-level digital learning competence (M= 2.70, SD= 0.78) and a low AI literacy level (M = 2.16, SD= 0.79) among the pre-service teachers. Significant relationship existed between digital learning competence and STEM achievement ($r = 0.403$, $p = 0.001$), digital learning competence and AI literacy jointly influenced STEM achievement $F(2, 597)=188.36$, $p < .001$; no gender disparity in STEM achievement ($t = -1.22$, $p >0.05$); and significant difference existed between university and college of education pre-service teachers' AI literacy level ($t = 3.78$, $p <0.01$). The study concluded that pre-service teachers' level of digital learning competence and AI literacy level were high and low respectively. These outcomes suggest that more AI literacy awareness should be created among pre-service teachers irrespective of their institutional type.

Keywords: digital learning competence, artificial intelligence literacy, STEM achievement, pre-service teachers, teacher education

1 Introduction

The increasing integration of digital technologies and artificial intelligence (AI) into education has transformed teaching, learning, and assessment, particularly in Science, Technology, Engineering, and Mathematics (STEM). Consequently, pre-service teachers require adequate digital learning competence and AI literacy to navigate digital learning environments, critically evaluate AI-generated information, and integrate emerging technologies into instructional practice. Digital learning competence encompasses the knowledge and skills needed to use digital tools effectively for learning, communication, collaboration, and problem-solving, while AI literacy involves understanding AI concepts, recognising its capabilities and limitations, and using AI responsibly. These competencies are increasingly important in teacher education because they may influence how future teachers engage with STEM content and develop the technological and analytical skills required for effective teaching (Long & Magerko, 2020).

Digital learning competence has become a fundamental component of teacher preparation, reflecting the capacity to use digital technologies effectively, critically, and responsibly to support learning and professional practice. It extends beyond basic computer operation to include information and data literacy, digital communication, collaboration, content creation, problem-solving, and safe and ethical engagement with technology. Redecker (2017) presents digital competence as a multidimensional construct encompassing educators' professional engagement, use of digital resources, teaching and learning, assessment, and the promotion of learners' digital competence. Similarly, UNESCO (2018) emphasises the integration of information and communication technologies into teaching, curriculum implementation, and professional development. These perspectives indicate that digital learning competence is not simply the ability to access digital tools but also the capacity to apply them meaningfully to educational activities.

The development of digital learning competence among pre-service teachers depends on individual capabilities and the learning environments in which those capabilities are developed. Dai (2023) identifies ICT self-efficacy, collegial collaboration, and infrastructural support as relevant considerations in understanding digital competence among pre-service teachers. Haşlaman et al. (2024) similarly demonstrate the relevance of examining pre-service teachers' digital competencies through a structured framework such as DigCompEdu. In addition, Getenet et al. (2026) draw attention to gender and learning mode in relation to pre-service teachers' digital competence and online engagement. Taken together, these studies suggest that digital competence develops through the interaction of technological access, confidence, opportunities for collaboration, and educational experiences. Consequently, assessing digital learning competence among pre-service teachers requires attention to more than their familiarity with digital devices or frequency of technology use.

In Nigeria, digital learning competence is particularly relevant to the preparation of future teachers as educational institutions increasingly engage with digital instructional resources, online learning platforms, and technology-supported assessment. Ogunmola and Alabi (2026) examine artificial intelligence awareness, digital competence, and technological pedagogical content knowledge among pre-service science teachers in southwestern Nigeria, connecting technology-related capabilities with the professional preparation of future educators. The findings and focus of this line of research make digital competence a relevant consideration in strengthening teacher education. However, differences in infrastructure, access to digital resources, and opportunities for practical engagement may influence the extent to which pre-service teachers develop these competencies. Therefore, determining the level of digital learning competence among Nigerian pre-service teachers is important for identifying their preparedness for technology-enhanced learning and examining whether this competence is associated with STEM academic achievement.

Artificial intelligence literacy refers to the knowledge, skills, and critical dispositions required to understand, use, evaluate, and interact responsibly with artificial intelligence systems. Long and Magerko (2020) conceptualise AI literacy through competencies that enable individuals to understand AI capabilities, recognise its limitations, and engage critically with AI-enabled technologies. Ng et al. (2021) likewise present AI literacy as a multidimensional construct involving knowledge and understanding, application, evaluation, and ethical considerations. These conceptualisations distinguish AI literacy from basic digital competence because effective interaction with AI requires an understanding of how AI systems operate, the limitations of their outputs, and the implications of using them. Accordingly, AI literacy should encompass not only awareness of AI applications but also the capacity to assess their accuracy, relevance, and ethical implications.

AI literacy is increasingly important in teacher education because AI-enabled applications can support lesson planning, instructional material development, formative feedback, and the explanation of complex concepts. However, these opportunities also introduce concerns about misinformation, algorithmic bias, privacy, transparency, and overdependence on automated systems. Miao and Holmes (2023) emphasise a human-centred approach to generative AI in education and research, highlighting the importance of appropriate safeguards and the preservation of human agency. Zawacki-Richter et al. (2019), in their systematic review of AI applications in higher education, also identify the importance of examining AI beyond its technical applications and considering the role of educators. Together, these perspectives suggest that pre-service teachers need the ability to use AI tools purposefully while maintaining professional judgement and responsibility for educational decisions.

In Nigeria, STEM pre-service teachers are expected to be the prospective teachers for STEM related subjects as they will eventually teach STEM subjects in schools. For them to deliver effectively in classrooms, they are not only expected to have the subject-matter knowledge but to possess good digital and AI literacy as required in the 21st century education. Despite the availability of digital and AI tools for teaching-learning, pre-service teachers in Southwest Nigeria still record poor academic performance in STEM courses. Many still lack adequate digital learning competence and AI literacy to use these tools effectively for STEM learning. Existing studies such as Ayanwale et al. (2024) provide particularly relevant Nigerian evidence concerning AI literacy, digital competence, and technological preparedness among pre-service teachers; and Shogbesan et al. (2026) which demonstrate the effectiveness of technology-driven on digital competence, but did not examine AI literacy as a distinct competence and as well didn't investigate the joint influence with digital learning competence on STEM academic performance. This study fills that gap. Building on this work, the present study brings these constructs together and also examines gender differences in STEM achievement and differences in AI literacy according to institutional type. However, the extent to which digital learning competence and AI literacy relate to STEM academic achievement requires further empirical investigation. Furthermore, potential differences in STEM achievement by gender and AI literacy by institutional type may provide useful insights into patterns of educational opportunity and the equitable development of technology-related competencies.

Hence, this study examines digital learning competence, AI literacy, and STEM academic achievement among pre-service teachers in Southwest Nigeria. Specifically, it assesses the levels of digital learning competence and AI literacy among pre-service teachers, investigates the relationship between digital learning competence and STEM academic achievement, examines the predictive contributions of digital learning competence and AI literacy to STEM achievement, compares STEM achievement across gender, and explores differences in AI literacy between pre-service teachers in public and private institutions. By investigating these variables within a single study, the research seeks to provide empirical evidence that can inform teacher education curricula, digital skills development, responsible AI integration, and strategies for strengthening STEM learning among future teachers in Southwest Nigeria.

Anticipated that Nigerian higher education system is in support of global technological advancements, comprehending the quality and future-ready pre-service teachers is key. Therefore, the study tends to answer and test the following research questions and hypotheses, respectively:

1. What is the level of digital learning competence of Pre-service teachers in Southwest Nigeria?
2. What is the level of AI literacy among Pre-service teachers in Southwest Nigeria?
3. What is the relationship between Pre-service teachers' digital learning competence and STEM academic achievement?
4. Do Pre-service teachers' digital learning competence and AI literacy predict their STEM achievement?
5. Is there a difference in Pre-service teachers' STEM achievement based on gender?
6. Is there a difference in Pre-service teachers' AI literacy based on institutional type?

Based on the research questions, the following corresponding hypotheses were tested.

H01: There is no significant relationship between Pre-service teachers' digital learning competence and STEM academic achievement.

H02: Pre-service teachers' digital learning competence and AI literacy do not significantly predict their STEM achievement.

H03: There is no significant difference in Pre-service teachers' STEM achievement based on gender.

H04: There is no significant difference in Pre-service teachers' AI literacy based on institutional type.

2 Literature Review

Digital learning competence and AI literacy are related constructs, but they represent different dimensions of technological preparedness. Digital learning competence concerns the ability to use digital tools for information management, communication, collaboration, content creation, and learning, whereas AI literacy focuses on understanding and evaluating AI systems and using them responsibly. Redecker (2017) provide complementary frameworks for understanding educators' digital competence, while Ng et al. (2021) explain the distinct knowledge and critical skills involved in AI literacy. Collectively, these frameworks suggest that general digital proficiency may facilitate engagement with AI applications, but it does not necessarily establish that an individual can evaluate AI-generated information or understand the ethical implications of its use. Digital learning competence may be associated with STEM achievement because students who use digital resources effectively can access academic information, engage with multimedia explanations, collaborate with peers, and explore complex concepts through digital tools. Dai (2023) highlights the relevance of ICT self-efficacy, collaboration, and infrastructural support to pre-service teachers' digital competence, while Haşlaman et al. (2024) examine digital competencies through a structured framework for educators. These studies support the importance of understanding digital competence as a multidimensional educational capability. However, whether this competence is associated with STEM achievement may depend on the quality of available resources, students' learning strategies, and the relevance of digital activities to their academic tasks. Digital competence should therefore be examined as a potential correlate of STEM achievement rather than treated as a direct cause of academic success.

AI literacy may also be relevant to STEM achievement because effective STEM learning involves evaluating evidence, interpreting information, testing explanations, and solving problems. Learners who understand AI capabilities and limitations may be better positioned to use AI-generated explanations as supplementary resources while verifying the information against credible academic materials. Ng et al. (2021) emphasise the critical and evaluative dimensions of AI literacy, while Miao and Holmes (2023) highlight the importance of responsible and human-centred AI use in education. These perspectives suggest that AI literacy may help learners engage more critically with AI-supported learning activities.

However, its relationship with academic achievement should be tested empirically, as AI literacy does not necessarily translate into higher performance in every subject or learning environment.

Research involving Nigerian pre-service teachers provides a useful foundation for examining these relationships. Ayanwale et al. (2024) investigate AI literacy among pre-service teachers, while Adam et al. (2026) focus on AI literacy among pre-service STEM teachers. Ogunmola and Alabi (2026) further examine AI awareness, digital competence, and technological pedagogical content knowledge among pre-service science teachers in southwestern Nigeria. Although these studies address relevant dimensions of technological preparedness, the simultaneous examination of digital learning competence, AI literacy, and STEM academic achievement remains an important area for further empirical inquiry. Considering the constructs together may help establish whether they are associated with STEM achievement and whether digital learning competence and AI literacy provide complementary explanatory information.

Empirical research has increasingly examined AI literacy among university students and pre-service teachers. Kong et al. (2022) investigated AI literacy courses in relation to conceptual learning, literacy, and empowerment among university students, demonstrating the relevance of structured educational experiences in developing AI-related competencies. Ayanwale et al. (2024) examined AI literacy among Nigerian pre-service teachers, providing context-specific evidence on the relevance of AI literacy to future classroom practice. More recently, Adam et al. (2026) investigated AI literacy among pre-service STEM teachers, reflecting the growing attention to AI preparedness within STEM teacher education. These studies collectively establish AI literacy as a relevant area of inquiry in preparing future educators. Nevertheless, AI literacy should be distinguished from general digital competence: proficiency in using online platforms does not necessarily indicate an understanding of AI-generated outputs, algorithmic limitations, or responsible AI use. Examining both constructs among Nigerian pre-service teachers can therefore provide a more comprehensive understanding of their readiness for technology-enhanced education.

STEM academic achievement refers to students' attainment in Science, Technology, Engineering, and Mathematics, reflecting their mastery of subject content and ability to apply concepts to academic and practical problems. STEM learning often involves analytical reasoning, quantitative interpretation, evidence-based decision-making, and the application of theoretical knowledge to unfamiliar situations. The Organisation for Economic Co-operation and Development (OECD, 2023) highlights the importance of learning outcomes and educational equity in understanding students' academic performance. For pre-service teachers, achievement in relevant STEM subjects is particularly important because their subject knowledge and problem-solving capabilities may influence their preparedness to teach scientific and mathematical concepts effectively. Digital technologies offer opportunities to support STEM learning through interactive simulations, virtual laboratories, multimedia explanations, online academic resources, and collaborative problem-solving activities. UNESCO (2018) emphasises the educational integration of digital technologies, while Redecker (2017) identifies the effective use of digital resources for teaching and learning as a central dimension of educators' digital competence. Scherer et al. (2019), through their meta-analytic investigation of the technology acceptance model, further demonstrate the importance of understanding factors associated with teachers' adoption of digital technology. These perspectives provide a basis for considering how digital learning competence may help students engage with technology-supported academic activities. However, access to digital resources or willingness to use technology should not automatically be interpreted as evidence of higher academic achievement. The relationship requires direct empirical investigation.

Artificial intelligence offers additional possibilities for STEM learning through personalised explanations, automated feedback, and support for problem-solving. Hasan and Khan (2023) investigated an AI-based intervention intended to improve undergraduate STEM learning, illustrating the relevance of AI-supported approaches to academic learning. Zawacki-Richter et al. (2019) also document the expanding use of AI applications in higher education, providing a broader context for understanding AI's potential educational role. Nevertheless, the educational usefulness of AI depends partly on how learners interpret and evaluate its outputs. Students who accept generated information without verification may misunderstand concepts or rely on inaccurate explanations. It is therefore important to examine digital learning competence and AI literacy in relation to STEM achievement rather than assuming that technological engagement necessarily leads to better academic outcomes.

Gender differences in STEM academic achievement remain an important subject in educational research because students may experience different learning opportunities, expectations, and educational environments. Nevertheless, achievement patterns should not be assumed to favour one gender consistently across subjects and settings. Wrigley-Asante et al. (2023) examined gender differences in STEM academic performance at the University of Ghana, providing evidence from an African higher education context. The broader emphasis on learning outcomes and educational equity in the OECD (2023) report also supports the importance of examining academic performance within the contexts in which students learn.

Together, these sources indicate the relevance of investigating gender-related achievement patterns without presuming their direction or attributing any observed differences to gender alone. Among Nigerian pre-service teachers, comparing STEM achievement by gender may help establish whether meaningful differences are present within the study population. Such differences, if observed, should be interpreted in relation to the particular subjects, institutional conditions, and educational experiences represented in the sample. Gender alone does not establish the reasons for academic performance, and additional evidence would be needed to explain any differences. Examining gender patterns can nevertheless help teacher education institutions understand the distribution of STEM achievement and identify areas that may warrant further research or educational support.

Institutional ownership or type may also be relevant to AI literacy because public and private institutions can differ in infrastructure, digital learning resources, curriculum implementation, and opportunities for students to engage with AI applications. Dai (2023) identifies infrastructure as a relevant consideration in digital competence, while Getenet et al. (2026) examine digital competence in relation to gender and learning mode. Ogunmola and Alabi (2026) provide a Nigerian teacher education context for examining technology-related competencies among pre-service science teachers. These studies suggest that the development of technology-related competence should be considered in relation to the educational conditions in which students learn. However, institutional ownership is not itself a direct measure of technological provision, and considerable differences may exist among institutions within the same ownership category. Comparing AI literacy between public and private institutions can therefore help determine whether differences are present in the study population, although further research may be required to identify the institutional factors responsible.

The reviewed literature establishes digital learning competence and AI literacy as important, related dimensions of contemporary teacher preparation. Haşlaman et al. (2024) provide frameworks and empirical perspectives for understanding digital competence in educational settings. Ng et al. (2021), and Miao and Holmes (2023) highlight the knowledge, evaluative skills, and ethical considerations required for responsible engagement with AI. Meanwhile, Hasan and Khan (2023) examine an AI-based approach to STEM learning, and Wrigley-Asante et al. (2023) provide evidence relevant to gender differences in STEM achievement. These contributions establish a conceptual and empirical foundation for investigating technology-related competencies and academic performance among future teachers.

3 Method

This study employed a descriptive survey research design of the correlational and cross-sectional type, comprising 600 respondents drawn from six (6) Colleges of Education and Universities in South-west, Nigeria. It involves the Adeyemi Federal University of Education, Ondo; University of Lagos; Osun State University, Osogbo; Federal College of Education (Special), Oyo; Federal College of Education, Osiele, Abeokuta and the College of Education, Ilawe-Ekiti. A researchers-designed questionnaire and a STEM achievement test (questionnaire) were used for data collection, and were analysed using descriptive and inferential statistics. A multi-stage sampling technique was adopted for this study. In stage 1, the South-West was stratified by State and one institution was purposively selected from each of the six states. In stage 2, only Faculty of Education pre-service teachers offering STEM-related courses were purposively selected. In stage 3, approximately 100 respondents were selected from each institution, making a total of 600 respondents. Validation of the instrument was carried out by Five educational technology experts from University of Ilorin, University of Lagos and Osun State University to ensure face, construct and content validity of the instrument. Suggestions and modifications made were effected in producing the final draft of the research instrument.

The reliability of the instrument was determined using Cronbach's alpha reliability test with the data collected after the pilot study. The sample for the pilot study were sixty (60) pre-service teachers of University of Ilorin, Ilorin, Kwara State, which were not among the intended samples for this study. The Cronbach alpha result equals 0.78 which implies the instrument was reliable. Mean score and percentage were used to answer research questions 1 and 2. A grand mean score of 2.50 and above was set as indicating a high level of digital learning competence or AI literacy and vice versa using 4-point Likert scale. This bench mark provided a clear yardstick for interpreting the overall understanding and readiness of the respondents. Institutional permission was sought from the authorities of the selected universities and colleges of education before administering the research instrument. Respondents' informed consent was also sought, and no coercion was applied. The confidentiality of their data was guaranteed. Hypotheses were tested using Pearson's Product Moment Correlation Coefficent (PPMC) for hypothesis 1, multiple regression for hypothesis 2, independent sample t-test for hypothesis 3 and 4, using SPSS version 25. These statistical tools were appropriate for determining if there were significant differences in mean scores between the two groups or not, and for determining relationship respectively.

4 Results

4.1 Respondents' Demographic Data

Table 1 displays a general profile of the 600 respondents who partook in this study, describing their distribution across important demographic variables: gender and school ownership. The total number of male respondents were 323 (53.8%), female respondents were 277 (46.2%), universities respondents were 304 (50.7%) and Colleges of Education respondents were 296 (49.3%). This shows that male students slightly formed higher number of respondents, while universities respondents has a little edge higher number of respondents.

Table **1**

Distribution of Respondents based on Gender and School Ownership

		Frequency	Percentage (%)
Gender	Male	323	53.8
	Female	277	46.2
Institutional Type	Respondents from Universities	304	50.7
	Respondents from Colleges of Education	296	49.3
	Total	**600**	**100.0**

4.2 Pre-service Teachers' Level of Digital Learning Competence

Table 2 reveals the pre-service teachers' level of digital learning competence. All the items tested in table 2 shows that the level of digital learning competence of pre-service teachers is high as most of the items tested were above the average benchmark of 2.50, except few. Items that yielded results above the benchmark 2.50 were positive items and they are; "I can personally produce digital content such as videos, slides, and quizzes for STEM lessons" with mean score 2.83; "I can successfully make use of digital tools like Zoom, Google Classroom, and Canva for teaching and learning" with mean score 2.93; "I know how to keep digital safety, avoid plagiarism and privacy intruding when using online resources" with mean score 2.95; "I can resolve basic ICT glitches like projector issues, internet connection malfunctioning, and software errors during lessons" with mean score 2.96; "I can personally use data analysis tools such as Excel, SPSS or Google Sheets to display STEM data" with mean score 2.88, among others. The grand mean score was 2.70 using the benchmark 2.50, it can be inferred that the pre-service teachers' level of digital learning competence is high.

Table **2**

Pre-service Teachers' Digital Learning Competence

S/N	Items	Mean (X)	SD	%
1.	I can personally produce digital content such as videos, slides, and quizzes for STEM lessons.	2.83	0.78	70.75
2.	I can successfully make use of digital tools like Zoom, Google Classroom, and Canva for teaching and learning.	2.93	0.78	73.25
3.	I know how to keep digital safety, avoid plagiarism and privacy intruding when using online resources.	2.95	0.78	73.75
4	I can resolve basic ICT glitches like projector issues, internet connection malfunctioning, and software errors during lessons.	2.96	0.78	74.00
5.	I can personally use data analysis tools such as Excel, SPSS or Google Sheets to display STEM data.	2.88	0.78	72.00

S/N	Items	Mean (X)	SD	%
6.	I am eloquent in searching, citing and evaluating online academic resources for STEM topics.	2.84	0.78	71.00
7.	I frequently update my digital skills in order to meet up with new educational technologies.	2.05	0.78	51.25
8.	I can collaborate with colleagues online through tools like WhatsApp and Google Docs for group STEM projects.	2.99	0.78	74.75
9.	I am happy when integrating simulations or virtual realities into STEM teaching.	1.81	0.80	45.25
10.	I can adjust my teaching methods to different digital learning platforms based on learners' needs.	2.78	0.79	69.50
	Grand Mean (X)	**2.70**	**0.78**	

4.3 Pre-service Teachers' Level of AI Literacy

Table 3 reveals the pre-service teachers' level of AI literacy. All the items examined in table 3 shows that pre-service teachers' level of AI literacy is low as all the items tested were below the average benchmark of 2.50 except for few items which are; I am eager to learn more regarding AI applications for learning STEM subjects, with mean score 2.52; I can use AI responsibly for research activities and learning, with mean score 2.58 and I can classify several AI tools like ChatGPT, adaptive tutors and Khanmigo used in STEM teaching-learning, with mean score 2.56. The grand mean score was 2.16, using the benchmark 2.50, it can be inferred that the pre-service teachers' level of AI literacy is low.

Table **3**

Pre-service Teachers' AI Literacy

S/N	Items	Mean (X)	SD	%
1.	I am eager to learn more regarding AI applications for learning STEM subjects.	2.52	0.78	63.00
2.	I am capable to use AI tools for producing lesson plans, prepare explanations and practical questions for STEM	1.73	0.78	43.25
3.	I can use AI responsibly for research activities and learning.	2.58	0.78	64.50
4	I consider AI to increase teaching effectiveness as well as STEM achievement.	2.12	0.78	53.00
5.	I understand the limitations of AI tools and when or not to rely on it for solving STEM problems.	1.65	0.78	41.25
6.	I can completely evaluate information made by AI tools before using them.	1.97	0.84	49.25
7.	I believe in using AI tools to personalize learning for learners with diverse abilities in STEM.	2.15	0.78	53.75
8.	I know the ethical considerations in using AI in education like privacy, being bias, and accuracy.	2.26	0.78	56.50
9.	I can classify several AI tools like ChatGPT, adaptive tutors and Khanmigo used in STEM teaching-learning.	2.56	0.78	64.00
10.	I recognise what Artificial Intelligence is and the way it works in education.	2.08	0.78	52.00
	Grand Mean (X)	**2.16**	**0.79**	

4.4 Relationship between Pre-service teachers' digital learning competence and STEM academic achievement

Table 4 presents the Pearson Product Moment Correlation analysis examining the relationship between Pre-service teachers' digital learning competence and STEM academic achievement. The results reveal a negative and significant correlation between the two variables (r = 0.403, p = 0.001). By implication, there is significant relationship between Pre-service teachers' digital learning competence and STEM academic achievement. Hence, the hypothesis was rejected.

Table **4**

Summary of Pearson Product Moment Correlation Showing Relationship between Pre-service teachers' digital learning competence and STEM academic achievement

Variable	Mean	Std. D	N	r	Sig(p)	Remark
Digital Learning Competence	2.70	0.24	600	.403	.001	Significant
STEM Academic Achievement	3.55	0.30				

Table **5**

Joint Prediction of Pre-service Teachers' STEM Achievement by Digital Learning Competence and AI Literacy

Model	R	R^2	Adjusted R^2	Std. Error	F	p-value
Digital Learning Competence and AI Literacy	0.622	0.387	0.385	0.235	188.36	< .001

Dependent Variable: *STEM Achievement*

Predictors: Digital Learning Competence and AI Literacy

Table **6**

Regression Coefficients

Predictor	B	Std. Error	Beta (β)	t	p-value	Decision
Constant	0.840	0.146	—	5.67	< .001	Significant
Digital Learning Competence	0.379	0.039	0.400	9.72	< .001	Significant
AI Literacy	0.294	0.037	0.327	7.95	< .001	Significant

The results indicate a strong positive relationship between the combined predictors and Pre-service teachers' STEM Achievement (R = .622). The model produced an R^2 of .387, indicating that the composite scores for both digital learning competence and AI literacy jointly explain 38.7% of the variance in STEM Achievement. The ANOVA result shows that the overall regression model is statistically significant, $F(2, 597) = 188.36$, $p < .001$. This indicates that digital learning competence and AI literacy jointly significantly predict Pre-service teachers' STEM achievement. Based on each variable, digital learning competence made the stronger contribution to pre-service teachers' STEM achievement ($\beta = .400$, $p < .001$), compared to AI literacy ($\beta = .327$, $p < .001$). Both predictors had statistically significant positive contributions. Since the overall regression model is significant, $F(2,597) = 188.36$, $p < .001$, the null hypothesis that digital learning competence and AI literacy do not jointly predict Pre-service teachers' STEM achievement is rejected**.** Hence, digital learning competence and AI literacy jointly and significantly predict Pre-service teachers' STEM achievement in Southwest, Nigeria.

4.5 Male and Female Pre-service Teachers' STEM Achievement

Table 7 gives an independent sample t-test analysis to establish whether there is significant difference between male and female Pre-service teachers' STEM achievement or not. The result shows that male respondents (N=323) exhibited a mean STEM achievement score of 3.54 (SD = 0.29) slightly lower than female respondents (N=277) which had a mean score of 3.57 (SD = 0.31). However, the statistics signified that the difference is statistically not significant. The t-test yielded a t-value of -1.22 with 598 degrees of freedom, and a two-tailed significance (p-value) of 0.22. Since the p-value of 0.22 is higher than the significance level of 0.05, the null hypothesis, stating that there is no significant difference between male and female Pre-service teachers' STEM achievement is not rejected. This implies that there is no significant difference between male and female Pre-service teachers' STEM achievement as both genders demonstrated similar level of achievement.

Table **7**

Independent sample t-test on Pre-service Teachers' STEM Achievement based on gender.

Gender	N	X	SD	df	t	Sig.2 (tailed)	Remark
Male	323	3.54	0.29	598	-1.22	0.22	Not Rejected
Female	277	3.57	0.31				
Total	**600**						

4.6 University and College of Education Pre-service Teachers' AI Literacy Level

Table 8 shows the findings of an independent samples t-test investigating whether there is significant difference between universities and college of education Pre-service teachers' AI literacy or not. However, the result shows that universities Pre-service (N=304) exhibited a mean AI literacy score of 2.21 (SD = 0.37) slightly higher than College of Education pre-service teachers (N=296) which had a mean score of 2.10 (SD = 0.32). However, the statistics specified that this difference is statistically significant. The t-test yielded a t-value of 3.78 with 598 degrees of freedom, and a two-tailed significance (p-value) of 0.00. Since the p-value of 0.00 is lower than the significance level of 0.05, the null hypothesis, stating that there is no significant difference between universities and college of education pre-service teachers on AI literacy, is rejected. This implies that universities pre-service teachers have slightly higher level of AI literacy than College of Education pre-service teachers in Southwest, Nigeria.

Table **8**

Independent sample t-test on Pre-service Teachers' AI Literacy based on school ownership

Institutional Type	N	X	SD	df	t	p-value	Remark
Respondents from Universities.	304	2.21	0.37	598	3.78	<.001	Rejected
Respondents from Colleges of Education	296	2.10	0.32				
Total	600						

5 Discussion

The study focused on examining digital learning competence and AI literacy of pre-service teachers on STEM achievement in South-west, Nigeria. Research question 1 examined digital learning competence level of pre-service teachers in Southwest, Nigeria. The result revealed that the digital learning competence level of pre-service teachers was high. This findings is in support of Saka and Olurinola (2026) which found out high digital proficiency among pre-service teachers. Contrarily, Onanuga and Saka (2025) found low digital competence among STEM pre-service teachers. Pre-service teachers' level of AI literacy was examined using research question 2. The result revealed that pre-service teachers have low level of AI literacy. The finding is in support of Tsakeni and Nwafor (2025) which reported that there was limited AI literacy among Pre-service teachers, meanwhile Jimba-Na'Allah et al. (2025) reported that there was high AI integration in teaching and learning practices by pre-service teachers. This contradiction among others justifies the present study.

The significant relationship between Pre-service teachers' digital learning competence and STEM academic achievement was tested by hypothesis 1. The result showed that there was a significant positive relationship between digital learning competence and STEM academic achievement. By implication, there was significant relationship between Pre-service teachers' digital learning competence and STEM academic achievement. This shows that pre-service teachers' digital learning competence is related to their STEM achievement. Also, the joint significant prediction of Pre-service teachers' digital learning competence and AI literacy on STEM achievement was tested by hypothesis 2. The multiple regression result showed that digital learning competence and AI literacy jointly had a significant influence on STEM academic achievement. By implication, there is joint significant predictions of digital learning competence and AI literacy on Pre-service teachers' STEM achievement. The significant difference between male and female Pre-service teachers' STEM achievement was tested by hypothesis 3. The result of the mean scores showed that the null hypothesis was not rejected. By implication, there was no significant difference between male and female Pre-service teachers' STEM achievement. This shows that both male and female Pre-service teachers have similar level of STEM achievement. Also, the significant difference between universities and colleges of education pre-service teachers on AI literacy level was tested by hypothesis 4. The result of the mean scores showed that the null hypothesis was rejected. By implication, there is significant difference between universities and colleges of education pre-service teachers on AI literacy. The result further shows that universities pre-service teachers have slightly higher AI literacy level more than the college of education pre-service teachers.

Hence, it was concluded that pre-service teachers' level of digital learning competence is high but the AI literacy is low. However, there was significant relationship between digital learning competence and STEM achievement; digital learning competence and AI literacy jointly predict the STEM achievement of pre-service teachers; there was no significant difference between male and female pre-service teachers' STEM achievement and there was significant difference between universities and college of education pre-service teachers on AI literacy level. Despite these treasured insights, the research is not without limitations. It focused exclusively on pre-service teachers in six institutions within South-west, Nigeria, which could limit the generalizability of the outcomes to other regions or higher education contexts. The use of researcher-designed questionnaires may also present bias due to social appeal or misunderstanding of questionnaire items. Future researchers could explore on objective AI literacy test, multi-institution probability samples, other moderating variables such as year of study, programme among others.

6 References

Adam, U. A., Bamiro, N. B., Usman, M., Owolabi, T., Oladejo, A. I., & Gbeleyi, O. A. (2026). Preparing future STEM educators: Investigating artificial intelligence literacy among pre-service STEM teachers. *STEM Education*, *6*(4), 514–538. https://doi.org/10.3934/steme.2026022

Ayanwale, M. A., Adelana, O. P., Molefi, R. R., Adeeko, O., & Ishola, A. M. (2024). Examining artificial intelligence literacy among pre-service teachers for future classrooms. *Computers and Education: Open*, *6*, Article 100179. https://doi.org/10.1016/j.caeo.2024.100179

Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2021). Emergency remote teaching in higher education: Mapping the first global online semester. *International Journal of Educational Technology in Higher Education*, *18*, Article 50. https://doi.org/10.1186/s41239-021-00282-x

Dai, W. (2023). An empirical study on English preservice teachers' digital competence regarding ICT self-efficacy, collegial collaboration and infrastructural support. *Heliyon*, *9*(9), Article e19538. https://doi.org/10.1016/j.heliyon.2023.e19538

Getenet, S., Haeusler, C., Redmond, P., Cantle, R., & Crouch, V. (2026). Bridging the digital divide: Gender and learning mode impacts on pre-service teacher digital competence and online engagement. *Irish Educational Studies*, *45*(1), 9–25. https://doi.org/10.1080/03323315.2024.2359694

Hasan, M. R., & Khan, B. (2023). An AI-based intervention for improving undergraduate STEM learning. *PLOS ONE*, *18*(7), Article e0288844. https://doi.org/10.1371/journal.pone.0288844

Haşlaman, T., Atman Uslu, N., & Mumcu, F. (2024). Development and in-depth investigation of pre-service teachers' digital competencies based on DigCompEdu: A case study. *Quality & Quantity*, *58*(1), 961–986. https://doi.org/10.1007/s11135-023-01674-z

Jimba-Na'Allah, F. K., Bolaji, H. O., Hassan-Ibrahim, R. B., Shittu, S. A., & Saliu, O. J. (2025). Harnessing AI for inclusive and innovative learning and research among pre-service biology teachers' in Kwara State Colleges of Education. *International Journal of Innovative Technology Integration in Education*, *7*(1), 1-15. https://ijitie.aitie.org.ng

Kong, S.-C., Cheung, W. M.-Y., & Zhang, G. (2022). Evaluating artificial intelligence literacy courses for fostering conceptual learning, literacy and empowerment in university students: Refocusing to conceptual building. *Computers in Human Behavior Reports*, *7*, Article 100223. https://doi.org/10.1016/j.chbr.2022.100223

Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1–16). Association for Computing Machinery. https://doi.org/10.1145/3313831.3376727

Miao, F., & Holmes, W. (2023). Guidance for generative AI in education and research. UNESCO. https://www.unesco.org/en/articles/guidance-generative-ai-education-and-research

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, *2*, Article 100041. https://doi.org/10.1016/j.caeai.2021.100041

Ogunmola, O. A., & Alabi, T. A. (2026). Artificial intelligence awareness, digital competence and technological pedagogical content knowledge of pre-service science teachers in federal universities in Southwestern Nigeria. Ife *Journal of Educational Studies*, *23*(1). https://ijes.oauife.edu.ng/index.php/ijes/article/view/21

Onanuga, P. A., & Saka, A. O. (2025). Emerging digital technologies: Building competencies of STEM pre-service teachers. *Journal of Teaching and Learning*, *19*(1), 155–169. https://doi.org/10.22329/jtl.v19i1.8810

Organisation for Economic Co-operation and Development. (2023). PISA 2022 results (Volume I): The state of learning and equity in education. OECD Publishing. https://doi.org/10.1787/53f23881-en

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu (Y. Punie, Ed.). Publications Office of the European Union. https://doi.org/10.2760/159770

Saka, A. O., & Olurinola, O. D. (2026). From pre-service to professional: Assessing future educators' information literacy proficiency to evaluate online teaching resources. *Journal of Humanities, Social and Creative Arts*, *21*, 109–121. https://journal.funaab.edu.ng

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, 128, 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Shogbesan, Y. O., Iwintolu, R. O., Akindahunsi, O. F., Zakariya, Y. F., Apata, S. B., & Abdulganiyu, A. B. (2026). Future-ready educators: Assessing the effectiveness of technology-driven intervention in preparing pre-service teachers for 21st-century classrooms. *Frontiers in Education*, *11*, Article 1852986. https://doi.org/10.3389/feduc.2026.1852986

Tsakeni, M., & Nwafor, S. C. (2025). Assessing artificial intelligence literacy among pre-service science teachers: Challenges and strategies for improvement. *International Journal of Learning, Teaching and Educational Research*, *24*(11), 356–375. https://doi.org/10.26803/ijlter.24.11.17

UNESCO. (2018). UNESCO ICT competency framework for teachers (Version 3). UNESCO.

Wrigley-Asante, C., Ackah, C. G., & Frimpong, L. K. (2023). Gender differences in academic performance of students studying Science Technology Engineering and Mathematics (STEM) subjects at the University of Ghana. *SN Social Sciences*, *3*(1), Article 12. https://doi.org/10.1007/s43545-023-00608-8

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *International Journal of Educational Technology in Higher Education*, *16*, Article 39. https://doi.org/10.1186/s41239-019-0171-0

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