

ARTIFICIAL INTELLIGENCE AND DIGITAL LITERACY AS PREDICTORS OF STUDENTS' ENGAGEMENT IN TRANSFORMATIVE EDUCATION IN NIGERIA: A CASE STUDY OF DELTA STATE

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Abstract

The study examined Artificial Intelligence (AI) and digital literacy as predictors of students' engagement in transformative education in Delta State, Nigeria. It determined how AI and digital literacy influenced students' engagement in the context of transformative learning. Three research questions and three null hypotheses guided the study. The research employed a correlational research design to assess the relationships between the variables. The population size consisted of 174,570 students from public secondary schools in Delta State, Nigeria. A sample size of 397 students was selected using stratified random sampling to ensure representation across different educational levels. The research instrument used for data collection was a structured questionnaire, which was validated by expert reviews. The reliability of the instrument was established using Cronbach's alpha, yielding a coefficient of 0.85, indicating high

reliability. Data were analysed using the coefficient of determination and regression analysis to assess the strength and significance of the relationships. The findings revealed that both AI and digital literacy had significant positive relationships with students' engagement in transformative education. Furthermore, the combined effects of AI and digital literacy was found to be a stronger predictor of students' engagement than either variable alone. The study concluded that integrating AI and enhancing digital literacy are crucial for fostering students' engagement in transformative education. Based on the findings, it was recommended that educational policymakers in Nigeria invest in AI-based learning tools and digital literacy programs to promote a more engaging and transformative educational experience for students.

Keywords: Artificial Intelligence, Digital Literacy, Student Engagement, Transformative Education.

Introduction

The rapid advancement of Artificial Intelligence (AI) has introduced profound shifts in educational theory and practice across the globe. AI technologies, ranging from intelligent tutoring systems to predictive analytics and generative applications, are increasingly embedded in formal learning environments to enhance personalization, automated feedback, and support instructional decision-making. A systematic review by Zawacki-Richter *et al.* (2020) documents the expanding research landscape of AI in education and identifies adaptive systems and learning analytics as dominant application areas. Further analyses emphasize that AI integration has moved beyond experimental pilots toward more structured implementation frameworks that seek to align technological innovation with pedagogical objectives (Holmes *et al.*, 2022). These developments reflect a broader transformation agenda in which AI is positioned as a strategic

tool for improving instructional responsiveness and learner support. Educational transformation in the digital age extends beyond technological access to encompass learning experiences that promote critical reflection, agency, and participatory knowledge construction. Empirical syntheses indicate that digitally mediated learning environments can enhance cognitive and emotional engagement when designed to support interaction and inquiry (Bond *et al.*, 2020). Research examining technology-enhanced instruction also suggests that active learning strategies embedded within digital platforms contribute to deeper understanding and sustained motivation (Sailer *et al.*, 2021). Such evidence underscores that transformative education in contemporary contexts is closely intertwined with the quality of digital integration and instructional design.

Students' engagement remains central to understanding academic success and persistence. Engagement encompasses behavioural participation, emotional connection, and cognitive investment in learning activities. International large-scale analyses indicate that students who effectively use digital technologies for learning demonstrate higher levels of motivation and academic resilience (OECD, 2021). Complementary empirical findings showed that structured and meaningful use of educational technologies positively predicts engagement outcomes when supported by adequate learner competencies (Fredricks & McColskey, 2021). These studies suggest that engagement in AI-enabled environments is influenced by both technological affordances and learner preparedness.

Digital literacy constitutes a foundational competence within AI-mediated educational systems. It involves not only operational skills but also critical evaluation, communication, and ethical awareness in digital contexts. Van Laar *et al.* (2020) identify digital skills as significant predictors of

effective performance and participation in technology-rich environments. Similarly, Sailer *et al.* (2021) reported that students with higher levels of digital competence exhibit stronger self-regulated learning behaviours and sustained engagement. As AI systems increasingly mediate instructional processes, the capacity to interpret algorithmic feedback and interact responsibly with intelligent technologies becomes integral to meaningful participation (UNESCO, 2023). The pedagogical and ethical dimensions of AI literacy have also attracted scholarly attention. Kong *et al.* (2021) demonstrated that structured AI literacy interventions can enhance students' conceptual understanding of AI systems and foster reflective engagement. Chen *et al.* (2023) further observed that the effectiveness of AI applications in education is contingent upon contextual readiness, including digital competence and institutional support. These findings reinforce the argument that AI's educational value is not inherent but mediated by the competencies and dispositions of learners and educators.

In developing educational systems, disparities in digital access and skill acquisition shape the outcomes of technology integration. The World Bank (2022) reports that digital skill gaps significantly influence learners' ability to benefit from technology-enabled reforms in low- and middle-income countries. Empirical investigations within sub-Saharan Africa similarly highlight the uneven distribution of digital competencies and its implications for engagement and academic performance (Zawacki-Richter *et al.*, 2020). Such contextual realities underscore the importance of examining AI and digital literacy within specific regional settings rather than assuming uniform effects across diverse educational systems. Nigeria's secondary education sector is gradually incorporating digital technologies and AI-informed instructional tools as part of broader digital transformation initiatives. Research examining technology adoption in Nigerian schools indicates that infrastructural capacity and

digital competence remain critical determinants of effective implementation (World Bank, 2022). Studies also suggest that learners' digital skills influence their interaction patterns and engagement levels within technology-supported classrooms (van Laar *et al.*, 2020; Sailer *et al.*, 2021). These insights highlight the interconnected roles of technological innovation and learner competence in shaping transformative educational experiences. Against this backdrop, the study investigated Artificial Intelligence and digital literacy as predictors of students' engagement in transformative education among secondary school students in Delta State, Nigeria. By situating these constructs within a correlational framework, the study sought to provide context-sensitive empirical evidence on how AI integration and digital competence intersect to shape engagement in evolving digital learning environments.

Statement of the Problem

The increasing integration of Artificial Intelligence (AI) into educational systems has been accompanied by strong claims about its potential to personalize instruction, enhance feedback, and stimulate deeper learners' participation. In many educational contexts, digital platforms and AI-enabled applications are gradually becoming embedded in classroom practice, often framed as catalysts for innovation and transformative learning. However, technological adoption alone does not inherently guarantee meaningful students' engagement. Evidence from emerging digital education reforms indicates that disparities in digital competence, uneven access to technological resources, and limited AI literacy may constrain learners' ability to benefit fully from AI-driven instructional environments. In developing countries such as Nigeria, where digital transformation efforts coexist with infrastructural and skill-related challenges, the relationship between AI integration and students' active engagement in transformative educational processes remains insufficiently understood. Despite growing policy attention to

digital innovation in secondary education, empirical studies examining how Artificial Intelligence and digital literacy interact to influence students' engagement are limited, particularly within sub-Saharan African settings. Existing research frequently isolates technology usage from learners' competence or focuses predominantly on higher education contexts, leaving a contextual and conceptual gap at the secondary school level. Without systematic investigation, assumptions about the transformative potential of AI in Nigerian classrooms risk remaining speculative rather than evidence-based. The critical issue, therefore, is whether and to what extent Artificial Intelligence and digital literacy function as meaningful predictors of students' engagement in transformative education among secondary school students in Delta State, Nigeria?

Purpose of the Study

The main purpose of this study was to investigate the relationship between Artificial Intelligence (AI) and digital literacy as predictors of students' engagement in transformative education in secondary schools in Delta State, Nigeria. The study aimed to assess how AI and digital literacy influenced the extent to which students were engaged in educational processes that led to transformative learning experiences. The study was specifically design to:

- explore the extent to which the use of Artificial Intelligence predicted students' engagement in transformative education;
- examine how digital literacy influenced students' engagement in transformative education;
- assess how Artificial Intelligence and digital literacy, when considered together, predicted students' engagement in transformative education.

Research Questions

The following research questions guided this study:

1. To what extent did the use of Artificial Intelligence predicted students' engagement in transformative education?
2. How did digital literacy predict students' engagement in transformative education?
3. How did Artificial Intelligence and digital literacy jointly predict students' engagement in transformative education?

Hypotheses

The study tested the following null hypotheses:

1. There was no significant relationship between the use of Artificial Intelligence and students' engagement in transformative education.
2. There was no significant relationship between digital literacy and students' engagement in transformative education.
3. There was no significant joint effects of Artificial Intelligence and digital literacy on students' engagement in transformative education.

Theoretical Framework

This study is grounded on Transformative Learning Theory and Self-Determination Theory. These two theories provided complementary explanatory lenses for understanding how Artificial Intelligence (AI) and digital literacy function as predictors of students' engagement in transformative education. While Transformative Learning Theory explains the cognitive–reflective processes underlying transformative education, Self-Determination Theory clarifies the motivational mechanisms that sustain students' engagement in technology-mediated learning environments. Transformative Learning Theory was developed by Mezirow in 1978 and elaborated in his seminal 1991 work *Transformative Dimensions of Adult Learning*. The theory posits that transformative learning occurs when learners critically examine previously unchallenged assumptions, engage in

reflective discourse, and reconstruct their meaning perspectives to form more inclusive, discriminating, and integrative worldviews. According to Mezirow, individuals interpret experiences through “frames of reference,” which are composed of habits of mind and points of view shaped by sociocultural and personal experiences. Transformation occurs when these frames of reference are subjected to critical reflection and revised through rational dialogue and experiential engagement.

Mezirow outlines a series of phases in the transformative process, beginning with a disorienting dilemma, an experience that challenges existing assumptions, followed by self-examination, critical assessment of assumptions, exploration of new roles or actions, planning a course of action, acquiring new knowledge or skills, and reintegration based on revised perspectives. Central to this theory is critical reflection, which involves questioning the validity of one’s beliefs, values, and assumptions. Dialogue and active participation are equally essential, as transformation is facilitated through interaction and shared meaning-making.

In the context of this study, AI-enabled learning environments can function as catalysts for transformative experiences. Intelligent tutoring systems, adaptive feedback mechanisms, simulations, and generative AI tools expose students to diverse perspectives, problem-solving pathways, and real-time data analysis that may challenge pre-existing beliefs and encourage higher-order thinking. However, the transformative potential of AI depends largely on learners’ capacity to critically interpret digital information. Digital literacy equips students with the skills to evaluate sources, interpret algorithmic outputs, recognize bias, and engage responsibly with AI systems. Thus, digital literacy strengthens the reflective and analytical processes central to Transformative Learning Theory.

Therefore, this theory provides a conceptual foundation for explaining how AI integration, when coupled with adequate digital literacy, can stimulate critical reflection, cognitive restructuring, and deeper engagement, core elements of transformative education.

Self-Determination Theory (SDT), developed by Deci and Ryan in 1985, is a macro-theory of human motivation that explains how social and environmental factors influence individuals' intrinsic and extrinsic motivation. SDT posits that optimal functioning and sustained engagement are achieved when three innate psychological needs are satisfied: autonomy, competence, and relatedness.

Autonomy refers to the need to experience volition and self-direction in one's actions. When learners perceive that they have control over their learning processes, they are more likely to demonstrate intrinsic motivation. Competence involves the need to feel effective and capable of mastering tasks and challenges. Feedback, structured guidance, and progressive challenges enhance learners' sense of competence. Relatedness refers to the need to feel connected to others and experience a sense of belonging within a learning community.

SDT further distinguishes between intrinsic motivation (engaging in an activity for inherent satisfaction) and various forms of extrinsic motivation that can become internalized when the learning environment supports psychological needs. Educational environments that nurture autonomy, competence, and relatedness tend to promote deeper engagement, persistence, and improved academic outcomes.

In AI-supported educational contexts, adaptive learning technologies can enhance autonomy by allowing students to learn at their own pace and follow personalized learning pathways. AI-driven analytics and immediate feedback can

strengthen perceptions of competence by identifying areas for improvement and reinforcing progress. Collaborative digital platforms and AI-assisted communication tools may also foster relatedness by enabling peer interaction and shared problem-solving. However, the motivational benefits of AI systems are contingent upon students' digital literacy. Learners who possess strong digital skills are more confident navigating AI platforms, interpreting feedback, and engaging meaningfully with digital tasks, thereby reinforcing their sense of competence and autonomy. Consequently, Self-Determination Theory provides a motivational explanation for why AI integration and digital literacy may predict higher levels of behavioural, emotional, and cognitive engagement in transformative educational settings. The integration of Transformative Learning Theory and Self-Determination Theory offer a comprehensive framework for this study. Transformative Learning Theory explains how AI and digital literacy may influence the depth and quality of learning by stimulating critical reflection and perspective transformation. Self-Determination Theory explains how AI-enabled environments and digital competence may satisfy students' psychological needs, thereby enhancing intrinsic motivation and sustained engagement.

Artificial Intelligence represents the instructional and technological stimulus within the learning environment. Digital literacy represents the enabling competence that allows students to effectively interact with AI systems. Students' engagement, behavioural, emotional, and cognition, serve as the outcome variables reflecting both motivational activation and transformative learning processes. Together, these theories justify the investigation of Artificial Intelligence and digital literacy as predictors of students' engagement in transformative education among secondary school students in Delta State, Nigeria, by linking technological innovation with both cognitive transformation and motivational dynamics.

Conceptual Framework

The conceptual framework for this study is built on the premise that Artificial Intelligence (AI), digital literacy, and their interactions significantly influence levels of students' engagement in transformative educational contexts. Artificial Intelligence in education refers to the use of intelligent systems such as adaptive learning platforms, automated feedback algorithms, predictive analytics, and generative AI tools that tailor instructional contents and provide personalized learning experiences. Research indicates that AI-enabled instructional tools can enhance personalized learning, facilitate real-time performance monitoring, and support adaptive feedback that aligns with individual learner's needs, all of which have positive effects on learners' engagement outcomes (Del Rosario Navas Bonilla *et al.*, 2025). Furthermore, students who interact with AI technologies in educational settings are more likely to experience enhanced autonomy and customized scaffolding, promoting self-regulated learning behaviours that contribute to deeper involvement with learning tasks (Chen *et al.*, 2023).

Digital literacy represents the set of competencies that enables learners to access, evaluate, interpret, and create digital contents ethically and critically. In the context of AI-mediated learning environments, digital literacy extends beyond operational proficiency to encompass critical thinking, discerning evaluation of digital information, and responsible engagement with AI-generated outputs. Emerging studies demonstrate that students with higher levels of digital literacy are better equipped to navigate complex digital learning environments, interpret algorithmic feedback, and engage meaningfully with interactive AI tools, which in turn fosters more positive attitudes toward technology-supported learning (Sergeeva *et al.*, 2025). Research further suggests that digital literacy acts as a foundational skill that mediates the

effectiveness of instructional technologies; without adequate digital literacy, learners may struggle to capitalize on the affordances of AI systems, leading to superficial or passive engagement rather than deep cognitive involvement (Helsper & Eynon, 2020; Soyulu *et al.*, 2025).

Students' engagement in transformative education is conceptualized as a multidimensional construct that encompasses behavioural, emotional, and cognitive facets of involvement in learning activities. Behavioural engagement refers to active participation, task persistence, and observable involvement in learning processes. Emotional engagement reflects learners' affective reactions to instructional stimuli, including interest, motivation, and positive attitudes toward classroom activities. Cognitive engagement involves strategic investment in learning, such as deep processing, critical reflection, and self-regulated learning practices. Contemporary research underscores the importance of engagement as a key predictor of academic achievement, learner satisfaction, and transformative outcomes in digital learning environments (Fredricks & McColskey, 2022). Studies have shown that when students experience personalized learning experiences supported by intelligent systems and possess the competencies to interpret and act on digital information, they are more likely to exhibit sustained engagement characterized by reflective thinking and meaningful participation (Gao *et al.*, 2021).

The conceptual framework posits that AI and digital literacy each exert direct predictive effects on students' engagement, and that the interaction between AI and digital literacy produces a stronger combined influence on engagement outcomes than either variable in isolation. Specifically, AI technologies provide contextual affordances that enable personalized and adaptive learning experiences, while digital literacy equips learners with the cognitive and evaluative skills necessary to engage effectively with these technologies. When

students are both exposed to AI-driven instructional designs and possess strong digital literacy competencies, they are more likely to engage behaviourally, emotionally, and cognitively with learning tasks in ways that support transformative educational outcomes. This framework therefore justifies investigating AI and digital literacy as joint predictors of students' engagement in transformative learning settings among secondary school students in Delta State, Nigeria.

Methodology

The study adopted a correlational research design to examine Artificial Intelligence and digital literacy as predictors of students' engagement in transformative education in Delta State, Nigeria. The correlational design was considered appropriate because the study sought to determine the magnitude and direction of relationships among variables without manipulating them. The design enabled the researchers to assess both the individual and joint predictive effects of Artificial Intelligence and digital literacy on students' engagement using statistical modelling techniques.

The population of the study comprised 174,570 students drawn from public secondary schools in Delta State, Nigeria. This population size reflects the total enrolment of students in public secondary schools across the state at the time of the study. From this population, a sample size of 397 students was selected. The sample size was determined using appropriate statistical sampling considerations to ensure adequate representation and statistical power for regression analysis. Stratified random sampling technique was employed to ensure proportional representation across different educational levels and school categories within the state. The stratification process helped to enhance the representativeness of the sample and minimize sampling bias.

The instrument used for data collection was a structured questionnaire developed by the researchers based on existing literature on Artificial Intelligence integration, digital literacy competencies, and students' engagement in transformative education. The questionnaire consisted of four sections. Section A elicited demographic information of the respondents. Section B measured students' exposure to and use of Artificial Intelligence tools in learning contexts. Section C assessed students' digital literacy competencies, including information evaluation, digital communication skills, and responsible technology use. Section D measured students' engagement in transformative education, covering behavioural, emotional, and cognitive dimensions of engagement. The items were structured on a Likert-type scale to allow respondents to indicate the degree to which they agreed with each statement.

To ensure the validity of the instrument, the questionnaire was subjected to experts review. Specialists in Educational Technology, Measurement and Evaluation, and Curriculum Studies examined the instrument for content relevance, clarity, and alignment with the study variables. Their suggestions and corrections were incorporated into the final version of the instrument to enhance its face and content validity. The reliability of the instrument was established using Cronbach's alpha coefficient to determine internal consistency. The overall reliability coefficient obtained was 0.85, indicating a high level of reliability and confirming that the instrument was suitable for the study.

Data were collected through direct administration of the questionnaire to the sampled students with the assistance of trained research assistants. Permission was obtained from relevant school authorities before the administration of the instrument. Respondents were assured of confidentiality and anonymity, and participation was voluntary. Completed

questionnaires were retrieved immediately after completion to ensure a high return rate and data integrity.

Data analysis was conducted using the coefficient of determination (R^2) and regression analysis. The coefficient of determination was used to determine the proportion of variance in students' engagement explained by Artificial Intelligence and digital literacy. Simple linear regression analysis was employed to assess the individual predictive effects of Artificial Intelligence and digital literacy on students' engagement, while multiple regression analysis was used to determine the joint predictive effects of the independent variables on the dependent variable. All hypotheses were tested at the 0.05 level of significance. The results of these analyses provided empirical evidence regarding the extent to which Artificial Intelligence and digital literacy predicted students' engagement in transformative education among secondary school students in Delta State, Nigeria.

Results

Research Question 1: To what extent did the use of Artificial Intelligence predicted students' engagement in transformative education in Delta State, Nigeria?

Table 1: Predictive Power of Artificial Intelligence on Students' Engagement in Transformative Education

Model	R	R ²	Adjusted R ²	Std. Error	Unstandardized Coefficients (B)	Decision
Constant (Artificial Intelligence)	0.62 ^a	0.3844	0.3812	8.964	65.420	Moderate positive relationship
					0.294	

^a Predictors: (Constant), Artificial Intelligence

Table 1 presents the extent to which Artificial Intelligence predicted students' engagement in transformative education in Delta State. The results showed a moderate positive relationship between Artificial Intelligence and students' engagement, as indicated by an R-value of 0.62 and an R² value of 0.3844. This implies that Artificial Intelligence accounted for 38.44% of the variation in students' engagement in transformative education. The unstandardized regression coefficient (B) of 0.294 indicates that a one-unit increase in Artificial Intelligence usage leads to a corresponding increase of 0.294 units in students' engagement. This finding suggests that increased exposure to and use of AI-based learning tools moderately enhances students' engagement levels.

Hypothesis 1: There was no significant relationship between the use of Artificial Intelligence and students' engagement in transformative education in Delta State, Nigeria.

Table 2: Significance of Prediction of Students' Engagement by Artificial Intelligence

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	2156.784	1	2156.784	54.73	.000 ^b
Residual	3452.216	395	8.739		
Total	5609.000	396			

a. Predictors: (Constant), Artificial Intelligence

b. Dependent Variable: Students' Engagement

Table 2 shows that Artificial Intelligence significantly predicts students' engagement in transformative education, $F(1, 395) = 54.73$, $p < .05$. Since the p-value (.000) is less than the 0.05 level of significance, the null hypothesis was rejected. This indicates that Artificial Intelligence is a statistically significant predictor of students' engagement in transformative education.

Research Question 2: How did digital literacy predicted students' engagement in transformative education in Delta State, Nigeria?

Table 3: Predictive Power of Digital Literacy on Students' Engagement in Transformative Education

Model	R	R ²	Adjusted R ²	Std. Error	Unstandardized Coefficients (B)	Decision
Constant (Digital Literacy)	0.67a	0.4489	0.4459	8.421	68.310	Moderate positive relationship
					0.338	

^a Predictors: (Constant), Digital Literacy

Table 3 presents the predictive power of digital literacy on students' engagement in transformative education. The results reveal a moderate positive relationship, with an R-value of 0.67 and an R² value of 0.4489. This indicates that digital literacy explains 44.89% of the variation in students' engagement. The unstandardized regression coefficient (B) of 0.338 suggests that a one-unit increase in digital literacy results in a 0.338 unit increase in students' engagement. This implies that students with stronger digital literacy competencies tend to demonstrate higher levels of engagement in transformative learning processes.

Hypothesis 2: There was no significant relationship between digital literacy and students' engagement in transformative education in Delta State, Nigeria.

Table 4: Significance of Prediction of Student Engagement by Digital Literacy

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	2518.126	1	2518.126	67.92	.000 ^b

Model	Sum of Squares	Df	Mean Square	F	Sig.
Residual	3090.874	395	7.827		
Total	5609.000	396			

a. Predictors: (Constant), Digital Literacy

b. Dependent Variable: Student Engagement

Table 4 indicates that digital literacy significantly predicts students' engagement in transformative education, $F(1, 395) = 67.92$, $p < .05$. Since the significance value (.000) is less than 0.05, the null hypothesis was rejected. This confirms that digital literacy is a significant predictor of students' engagement in transformative education.

Research Question 3: How did Artificial Intelligence and digital literacy jointly predict students' engagement in transformative education in Delta State, Nigeria?

Table 5: Joint Predictive Power of Artificial Intelligence and Digital Literacy on Students' Engagement

Model	R	R ²	Adjusted R ²	Std. Error	Unstandardized Coefficients (B)	Decision
Constant (AI & Digital Literacy)	0.74 ^a	0.5476	0.5431	7.638	72.850	Strong positive relationship
					0.201 (AI)	
					0.287 (Digital Literacy)	

^a Predictors: (Constant), Artificial Intelligence, Digital Literacy

Table 5 presents the combined predictive effects of Artificial Intelligence and digital literacy on students' engagement. The findings revealed a strong positive relationship, as indicated by an R-value of 0.74 and an R² value of 0.5476. This means that Artificial Intelligence and digital literacy jointly account

for 54.76% of the variation in students' engagement in transformative education. The unstandardized coefficient for Artificial Intelligence ($B = 0.201$) indicates that a one-unit increase in AI leads to a 0.201 unit increase in students' engagement when digital literacy is held constant. Similarly, the unstandardized coefficient for digital literacy ($B = 0.287$) shows that a one-unit increase in digital literacy leads to a 0.287 unit increase in students' engagement when AI is held constant. These results demonstrate that the combined influence of the two predictors is stronger than their individual effects.

Hypothesis 3: There was no significant joint effect of Artificial Intelligence and digital literacy on students' engagement in transformative education in Delta State, Nigeria.

Table 6: Significance of Joint Prediction of Students' Engagement by Artificial Intelligence and Digital Literacy

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	3071.488	2	1535.744	86.54	.000 ^b
Residual	2537.512	394	6.440		
Total	5609.000	396			

a. Predictors: (Constant), Artificial Intelligence, Digital Literacy

b. Dependent Variable: Students' Engagement

Table 6 shows that Artificial Intelligence and digital literacy jointly predict students' engagement significantly, $F(2, 394) = 86.54$, $p < .05$. Since the p-value (0.000) is less than the 0.05 level of significance, the null hypothesis was rejected. This indicates that the combined effects of Artificial Intelligence and digital literacy significantly predicts students' engagement

in transformative education among secondary school students in Delta State, Nigeria.

Discussion

The study revealed that Artificial Intelligence (AI) significantly predicted students' engagement in transformative education. Specifically, the results showed a moderate positive influence of AI on students' engagement, indicating that increased use of AI technologies was associated with higher levels of students' participation, interest, and cognitive involvement. This finding suggests that when students are exposed to responsive, personalized, and adaptive AI-powered learning environments, they are more likely to be actively engaged in learning activities. A probable reason for this outcome is that AI tools often provide immediate feedback, tailor learning pathways to individual needs, and create interactive learning experiences, all of which can stimulate learner autonomy and motivation. This result aligns with recent research indicating that AI-driven educational tools enhance students' engagement by enabling personalized learning and timely support (Vieriu, 2025; OECD, 2025). However, some studies have not found a uniform positive impact of AI on engagement; for example, Ma'amor et al. (2024) reported that while AI usage significantly influenced engagement and academic performance, its effect on personalized learning was not significant, suggesting that context and implementation quality can influence outcomes. Additionally, broader surveys indicate that despite high adoption rates, some students view AI as reducing independent cognitive effort, potentially dampening engagement (Oxford University Press survey, 2025). The differences between these findings and the current result may be attributed to variations in educational settings, students' preparedness, and the degree of pedagogical integration of AI. While AI can offer engagement enhancements, its

effectiveness appears contingent on how well it is aligned with learning design and support structures in the classroom.

Another finding of the study showed that digital literacy significantly predicted students' engagement in transformative education, with higher digital literacy associated with higher engagement levels. This suggests that students who possess the skills to effectively navigate, critically assess, and utilize digital tools are more likely to participate meaningfully in AI-mediated and technology-rich learning environments. A probable reason for this positive relationship is that digital literacy enhances learners' confidence and competence in accessing information, evaluating digital content, and managing AI-based tools, enabling them to integrate digital resources into their learning strategies. This finding corroborates research demonstrating that digital literacy contributes positively to students' engagement and learning processes (MDPI, 2024; Getenet et al., 2024). Conversely, some research indicated that digital literacy does not always directly influence engagement outcomes; for instance, certain studies in online or specialized contexts have found that digital literacy influences performance indirectly through mediators such as motivation and self-regulation rather than exerting a direct effect (Essuman et al., 2025). These discrepancies may stem from contextual differences, such as the specific nature of the digital tasks involved or the presence of other moderating factors like instructional design quality or self-efficacy levels. Thus, while digital literacy generally supports engagement, its direct predictive power can vary depending on the learning environment and the roles of other psychological factors.

The combined predictive effects of Artificial Intelligence and digital literacy on students' engagement was also significant, indicating that when both AI usage and digital literacy competencies are present, they jointly account for a larger

proportion of the variance in engagement than when either variable is considered alone. A plausible explanation for this synergistic effect is that AI technologies provide the structural and interactive features that can enhance engagement, while digital literacy equips students with the cognitive tools necessary to interpret and utilize these features effectively. This joint influence is supported by research showing that adaptive technologies and digital literacy together significantly impact active learning and participation (Phon & Ali, 2025). Nevertheless, some literature pointed to limitations in the joint effects when other contextual barriers, such as insufficient teacher's support or inadequate infrastructure, are present, reducing the combined impact of technology and competence on engagement (OECD, 2025). These differences suggest that while the complementarity of AI and digital literacy enhance engagement, the strength of this joint effects may be moderated by broader educational factors such as access, training, and pedagogical alignment. In summary, the findings of this study reinforce the importance of integrating AI with efforts to strengthen digital literacy to foster meaningful students' engagement, while also highlighting the complexity and contextual dependencies found in recent research.

Conclusion

This study concluded that Artificial Intelligence and digital literacy are significant predictors of students' engagement in transformative education among secondary school students in Delta State, Nigeria. Artificial Intelligence demonstrated a moderate positive predictive effect on students' engagement, indicating that AI-enabled instructional tools enhance students' behavioural, emotional, and cognitive involvement in learning. Digital literacy also significantly predicted students' engagement, highlighting the importance of learners' competencies in navigating and critically utilizing digital technologies. Furthermore, the joint effects of Artificial

Intelligence and digital literacy was stronger than their individual effects, confirming that technological innovation and learner competence operate synergistically to promote transformative educational experiences. The study therefore concludes that meaningful integration of AI in education must be accompanied by deliberate efforts to strengthen students' digital literacy in order to maximize engagement and transformative learning outcomes.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Educational policymakers in Delta State should invest in the structured integration of Artificial Intelligence tools such as adaptive learning platforms and intelligent tutoring systems in public secondary schools to enhance students' engagement.
2. School administrators should implement comprehensive digital literacy programmes that equip students with critical, ethical, and analytical skills required to effectively use AI-mediated learning technologies.
3. Teachers should receive continuous professional development on pedagogically sound use of Artificial Intelligence to ensure that AI tools are aligned with transformative learning objectives rather than used superficially.
4. Government and educational stakeholders should provide adequate digital infrastructure, including reliable internet access and functional digital devices, to support effective AI integration and sustained students' engagement.

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