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The Mediating Role of Students' Digital Literacy in the Relationship Between Artificial Intelligence Based Learning Tools and Academic Performance

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ABSTRACT

Artificial intelligence (AI) has become the inseparable part of the contemporary education that gives students adaptative and personalised learning experiences. Nevertheless, the effectiveness of AI-based learning tools in terms of academic performance can be predetermined by the skills of students to operate digital technologies. The purpose of this research was to examine how the mediating variable of digital literacy of the students influenced the relationship between the academic performance and AI-based learning tools. The cross-sectional correlational design was applied and a convenience sample of 243 university students enrolled in AI-supported courses located in Karachi, Pakistan. Three standardised measures were used, including AI-Based Learning Tools Utilisation Scale, Digital literacy competence Questionnaire, and Academic Performance Scale. To determine both direct and indirect effects, Pearson correlation coefficient and structural equation modelling (SEM) were used to analyse data. The results were meaningful positive correlations among AI-based learning tools and digital literacy ($r = 0.462$, $P \leq 0.01$), digital literacy and academic performance ($r = 0.418$, $P \leq 0.01$). The outcomes of the SEM showed that digital literacy was a strong mediator of the correlation between AI-based learning tools and academic performance (0.142, $P < 0.001$). The mediating effect of digital literacy among students, between the use of AI-based learning tools and academic performance, is quite notable. Boosting the digital literacy add more value to AI technologies and offer better learning results to students.

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1. Introduction

The introduction of AI in education has transformed traditional learning environments into dynamic, technology-driven ecosystems that offer adaptive and personalized learning

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experiences (Awad, 2025). Rapid advancements in AI technologies—such as intelligent tutoring systems, adaptive learning platforms, and automated feedback mechanisms—have created unprecedented opportunities to enhance teaching and learning outcomes (Qadeer & Awad, 2025). However, the effectiveness of AI-based learning tools depends not only on their technological capabilities but also on students' ability to comprehend, interpret, and utilize these tools effectively, a competency broadly referred to as digital literacy (Wahed et al., 2024). Digital literacy serves as a critical mediating factor, shaping how exposure to AI-driven tools translates into improved academic performance. In the contemporary educational context, digital literacy extends beyond basic technological skills to include cognitive, ethical, and critical engagement with digital resources (Aldabousi, 2023). It enables learners to interact efficiently with AI platforms, interpret algorithmic outputs, and make informed learning decisions. Empirical studies indicate that students with higher digital literacy exhibit greater adaptability and learning success in AI-enhanced environments (Awad, 2025; Aldabousi, 2022). Thus, while AI tools have the potential to provide individualized education and data-driven support, their educational impact can be limited by learners' digital competence.

The adoption of AI in higher education has become a global trend, particularly in Karachi, Pakistan, accelerated by the digitalization of universities during the COVID-19 pandemic (Awad et al., 2024). Over 70% of higher education institutions worldwide now employ AI-based learning platforms to monitor performance and engagement (Awad, 2025). Yet, disparities in digital literacy remain a key barrier to the equitable and effective use of these technologies (Awad et al., 2024). These disparities are especially pronounced in developing educational systems in Asia and the Middle East, where digital infrastructure is still evolving (Aldabousi, 2023). Investigating digital literacy as both background knowledge and a mediating factor in the AI-performance relationship is therefore crucial. Recent research highlights gaps in understanding this mediation. Qadeer and Awad (2025) found that AI tools enhance learning but do not directly predict performance without sufficient digital competence. Similarly, Wahed et al. (2024) noted that digital preparedness influences success in AI learning environments. While some studies report mixed results regarding AI's direct impact on academic achievement (Awad, 2025; Awad et al., 2025), others indicate that technology attitudes and digital literacy mediate learning outcomes (Ghonim et al., 2025; Yusuf et al., 2025; Khan et al., 2023; Khalifa et al., 2020). However, few studies provide a comprehensive empirical model integrating AI-based tools, digital literacy, and academic performance using advanced methods like structural equation modeling (SEM).

This research addresses that gap by examining the mediating role of digital literacy in the relationship between AI-based learning tools and academic achievement among university students. Specifically, it investigates whether increased engagement with AI platforms improves academic performance through the development of digital competence. The study's originality lies in its integrative approach, combining technological, cognitive, and performance dimensions in a single empirical model. By emphasizing digital literacy as a mediator, the study challenges the assumption that AI automatically enhances learning, highlighting the importance of human-technology interaction in predicting educational outcomes. The findings have both theoretical and practical implications for educators, policymakers, and institutions seeking effective AI integration. By narrowing the digital competency gap, AI-enhanced education can become more

inclusive and effective across diverse learning contexts. Methodologically, this quantitative, cross-sectional study employs validated scales for AI tool usage, digital literacy, and academic performance. SEM allows for the assessment of direct and indirect relationships, supporting a rigorous empirical examination of the proposed mediation mechanism. Overall, this research contributes to the literature on AI in education by conceptualizing digital literacy as the crucial link between AI learning applications and students' academic achievement. It demonstrates that the pedagogical potential of AI is realized only when learners are digitally literate, engaged, and empowered to leverage intelligent technologies for their learning advantage.

2. Theoretical Background

The current research is based on three theorists that are interconnected, such as Technology Acceptance Model (TAM), Cognitive Load Theory (CLT), and Self-Determination Theory (SDT), which have been adopted to give a strong theoretical framework of how the application of AI-based learning tools has impacted academic performance through the mediation of the digital literacy concept. All of these theories describe the behavioural, cognitive, and motivational processes through which technology adoption is related to learning outcomes, which allows approaching interactions between students and AI-enhanced educational settings multidimensionally. TAM (Davis, 1989) provides a theoretical basis of the role played by perceptions of users towards technology on their behavioural intentions and performance. When it comes to AI-based learning tools, the perceived usefulness and perceived ease of use are elements that define how successful the utilisation of these tools by students becomes. An increasing amount of literature has demonstrated that more digitally literate students indicate better technology acceptance and confidence in the usage of AI systems, as well as better academic success (Khan et al., 2022). According to Mahmoud et al (2025), digitally competent students have a higher tendency of finding AI tools useful in self directed learning, interactive feedback and performance improvement. In addition, digital literacy leads to the perceived ease of use because it minimises technological anxiety and enables easier navigation of AI-based interfaces (Mari and Hussain, 2021).

Therefore, in this context, digital literacy acts as a psychological and behavioural intermediary who transforms technology acceptance into the actual performance benefits. The Pakistani higher education setting suggested by the relatively diverse levels of exposure to AI technologies in students comprising a testing ground is of high importance (Alzboon et al., 2025). In this case, the digital divide is one of the essential problems, and digital literacy will make the difference between AI implementation and the achievement of valuable learning outcomes, as opposed to the superficial engagement of the tools. As TAM is used to explain behavioural acceptance, CLT (Sweller, 1988) describes the cognitive processes under which AI-based learning influences performance. The CLT theory suggests that in order to be an efficient learner, there is the need to control the intrinsic, extraneous and germane cognitive load. With adaptive algorithms, AI systems can customise the teaching process and reduce cognitive load that learners do not need, but this advantage only becomes possible when the learners are digitally literate enough to read,

process, and react to the information generated by AI (Awad, 2024; Khalifa et al., 2020). It is always empirically proved that more digitally literate students report having less cognitive overload, enhanced information retention, and enhanced problem-solving skills when interacting with intelligent tutoring systems (Ghonim et al., 2025; Alqaraleh, 2024). Studies carried out in different institutions of higher learning have shown that digital literacy decreases extraneous load through simplifying the interface interaction process and increases the germane load through more complex interaction with conceptual content (Ghonim & Awad, 2024).

Digital literacy is especially essential in the Pakistani educational setting, which is marked by a certain range of both digital readiness and lack thereof. Learners who lack technological proficiency can find it challenging to deal with cognitive overload, which will result in less learning effectiveness despite the availability of AI-powered resources (Hussain et al., 2022). Thus, CLT adds to the research that digital literacy is not only a background ability but a mediating cognitive attribute that can affect the success of AI tools in enhancing academic achievement. On a par with these cognitive and behavioural frameworks, SDT (Ghonim and Awad, 2025) offers a motivational viewpoint regarding the mediation process. SDT holds that there are three intrinsic psychological needs that influence learning behaviours as autonomy, competency and relatedness. The needs can be fulfilled by AI-based learning tools, which provide personalised feedback, self-paced learning, and interaction opportunities, but the motivational capabilities are subject to the digital literacy of the learner (Alzboon et al., 2023; Awad et al., 2025). More digitally literate students are also more likely to feel independent using AI systems, more able to use it academically, and more linked with the academic support of AI-based collaboration tools (Al-Batah et al., 2024; Awad et al., 2025). Research has shown numerous times that digital literacy contributes to intrinsic motivation of using learning technologies, which positively influence academic performance (Aldabousi, 2023). In the Pakistan situation, where there is a tendency to avoid using emergent educational technologies due to digital uncertainty, digital literacy is the psychological facilitator that will shift AI-based learning into an externally imposed focus on learning to a self-directed, competency-driven learning process (Aldabousi, 2022). In this regard, SDT would be clear about the internal processes in which digital literacy mediates the relationship between AI engagement and academic success.

Combining the theories gives a more detailed picture than any of the frameworks could give on its own. TAM describes the reasons why students are willing to use AI technologies; CLT describes how digital literacy affects the cognitive processing in AI contexts; and SDT explains the presence of motivation processes that help students to remain engaged and turn this engagement into improved performance. They provide complementary information about the behavioural, cognitive and affective aspects of the AI-digital literacy-performance correlation. Instead of being in tension, these frameworks come together to create a single explanatory model: digital literacy can be the key mechanism by which the three attributes of technological acceptance, cognitive efficiency, and intrinsic motivation together can improve academic outcomes. Nevertheless, most of the existing research has dealt with these frameworks individually and this has resulted in disjointed descriptions of technology-mediated learning. It has been previously identified that AI-based tools can enhance learning outcomes (TAM perspective), although their impact is not consistent when no cognitive or motivational variables are taken into account (CLT and SDT

perspectives). On the same note, the studies that exclusively examined the cognitive load or motivation did not pay attention to the behavioural antecedents of technology adoption. The theoretical gap that is highlighted by this fragmentation is that it is necessary to have an integrative model which would incorporate behavioural acceptance, cognitive processing and motivational regulation within the same empirical framework. This gap is addressed by the current research that synthesises TAM, CLT, and SDT into a unified conceptual construct, which creates digital literacy as the mediating factor between these dimensions. To sum everything up, the synthesis of the TAM, CLT, and SDT provides a coherent and multidimensional theoretical basis of this study. They all elaborate on the fact that digital literacy functions as the behavioural, cognitive and motivational channel that connects the AI-based learning tools to the academic performance of students. This combination of theoretical approaches does not only contribute to the academic knowledge but also provides the evidence-based insights to guide the development of the AI-based educational interventions that are cognitively effective, motivationally supportive, and digitally inclusive in the framework of the higher education.

2.1 AI-Based Learning Tools and Digital Literacy

The integration of AI into teaching and learning has redefined the relationships between students and digital systems, knowledge acquisition, and the development of essential twenty-first-century skills. AI-based learning applications—including adaptive tutoring systems, smart learning analytics, and automated feedback systems—enhance students' interest, engagement, and learning effectiveness by personalizing instruction and supporting autonomous learning processes (Alzboon et al., 2023). These technologies engage students in navigating, interpreting, and managing digital platforms, fostering the development of digital literacy skills (Alka'awaneh et al., 2025; Al-Tal et al., 2019). Digital literacy, defined as the ability to use, evaluate, and locate digital information and technologies efficiently, is a core outcome of modern education (Awad & Mahmoud, 2024). Empirical studies indicate that exposure to AI-based learning systems improves students' digital competence, increasing their awareness of data interpretation, problem-solving in virtual environments, and self-regulated learning behaviors (Ghonim & Awad, 2025; Awad, 2024). Further, both the quantity and quality of engagement with intelligent educational systems significantly predict the development of students' digital communication and cognitive processing skills (Aldabousi, 2024; Al-Sherman & Aldabousi, 2024). Theoretically, the TAM and SDT provide a framework for understanding these effects. TAM posits that perceived usefulness and ease of use motivate users to engage repeatedly with technology, thereby enhancing digital competence through meaningful interaction (Davis, 1989). Similarly, SDT suggests that AI-based learning fosters autonomy, competence, and intrinsic motivation, promoting deeper exploration of digital systems and increasing digital literacy (Sharma & Nagi, 2018). Al-Ramahi et al. (2024) found that students using AI-based platforms exhibited higher digital literacy than those in traditional classrooms. Almeer et al. (2024) reported that AI tools enhanced critical thinking and students' ability to integrate digital resources into academic work. These findings support the notion that AI-based technologies serve not only as learning tools but also as digital literacy tools, facilitating the development of skills essential for lifelong learning in technology-mediated contexts. Based on these theoretical and empirical insights, the following hypothesis is proposed:

H 1: The utilization of AI-based learning tools positively impact on students digital literacy.

2.2 Artificial Intelligence-Based Learning tools and Student Academic Performance

AI has become a transformative force in education, reshaping teaching practices and creating adaptive, data-driven learning environments that enhance academic outcomes. AI-based learning tools—such as intelligent tutoring systems, predictive analytics platforms, and automated assessment tools—provide students with personalized learning experiences tailored to their individual needs, learning pace, and cognitive styles (Alghizzawi et al., 2025; Aldabousi et al., 2025). This personalization promotes more effective learning activities, immediate feedback, and continuous performance monitoring, all of which contribute to improved academic performance (Aldabousi, 2025; Awad & Ghonim, 2025). Empirical studies support these benefits. Awad et al. (2025) reported that AI-assisted learning environments improve comprehension and retention through adaptive learning modules and real-time feedback. Similarly, Awad et al. (2024) found that AI-enhanced platforms strengthen conceptual understanding by identifying and addressing individual learning gaps. Nagi et al. (2023) demonstrated that AI learning analytics positively impact academic efficiency by increasing study time and detecting performance weaknesses early. The theoretical underpinning of this relationship can be traced to CLT, which posits that AI-based systems facilitate interactive, learner-centered environments that encourage active knowledge construction through real-time feedback and problem-based learning (Nagi & Bajiah, 2020; Yahia Shams Eldin et al., 2025). CLT also aligns with the notion that AI platforms reduce extraneous cognitive load by automating repetitive tasks and guiding students through structured, scaffolded learning pathways (Sweller, 1988). By effectively managing cognitive demands, AI tools allow learners to focus on acquiring relevant knowledge, thereby improving academic performance (Wahid & Awad, 2025). In addition, SRL Theory emphasizes that AI systems enable learners to plan, monitor, and adapt their learning strategies independently. Recent research indicates that AI tools can significantly enhance students' self-regulation and motivation, both of which are key predictors of academic achievement (Nahi, 2024; Wahed et al., 2025). Collectively, these theoretical and empirical findings suggest that AI-based learning tools not only support knowledge delivery but also foster personalized learning, engagement, and self-regulation, ultimately leading to improved academic performance. Based on these insights, the following hypothesis is proposed:

H2: The utilization of AI-based learning tools has a significant positive effect on students' academic performance.

2.3 Digital Literacy and Academic Performance

In the digital age, digital literacy has emerged as a core competence that significantly influences students' academic success. Digital literacy encompasses the ability to locate, analyze, generate, and share information, as well as to think critically, solve problems, engage ethically with digital content, and demonstrate technical proficiency (Wahed et al., 2024). In higher education, students' digital literacy determines the effectiveness of their engagement with learning resources, access to digital platforms, and integration of technological tools into academic

activities. Consequently, higher digital literacy is directly associated with enhanced learning efficiency, self-regulation, and overall academic performance (Obeidat et al., 2024; Saad et al., 2025). Empirical research supports this link. Sharma and Nagi (2015) found that students with greater digital competence achieve higher academic outcomes due to improved information-processing skills and application of knowledge. Similarly, Nagi (2024) reported that digitally literate students are better equipped to navigate complex online materials, collaborate in virtual environments, and employ higher-order cognitive strategies, leading to superior academic results. Saeed Almanbahi et al. (2025) further noted that digital literacy enhances students' adaptation to AI-based and online learning systems, increasing motivation and learning performance. Theoretically, CLT and SRLTheory explain the connection between digital literacy and academic performance. Constructivism emphasizes that knowledge is actively constructed through interaction and experience (Nagi et al., 2025). Students with higher digital literacy can navigate digitally enriched environments more effectively, understand and synthesize information, and engage in deeper comprehension and knowledge creation. SRL Theory suggests that digitally literate students are better at setting learning goals, monitoring progress, and adjusting strategies based on feedback, which enhances academic performance (Nagi & Nigam, 2023; Nagi et al., 2024). Recent studies also indicate that digital literacy strengthens the effectiveness of technology-enhanced learning. Nagi and Singh (2025) found that digital literacy strongly predicts students' ability to maximize the educational value of AI-based systems and online platforms. Qadeer and Awad (2025) reported that higher digital literacy improves information fluency and cognitive engagement, resulting in higher grades and greater satisfaction with learning. Collectively, theoretical and empirical evidence suggests that students with higher digital literacy can leverage technological resources more effectively, leading to enhanced learning experiences and improved academic performance. Based on these insights, the following hypothesis is proposed:

H3: student's Digital literacy has significant impact on students academic performance.

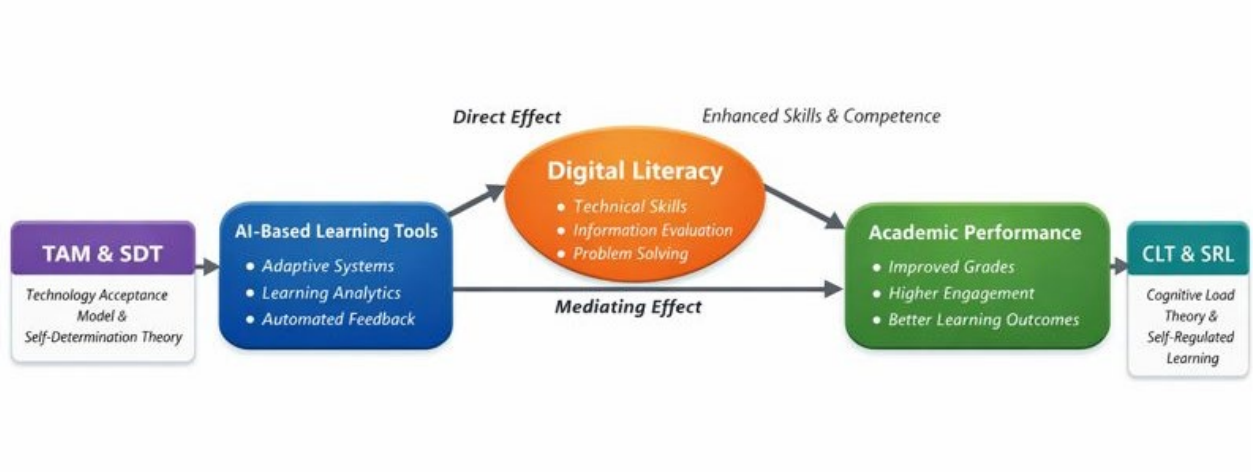
2.4 Mediating role of Digital Literacy

The adoption of AI in education has transformed how students acquire and apply knowledge, with digital competence serving as a critical link between technology use and learning outcomes. While AI-based learning technologies can directly enhance academic performance by providing personalized, adaptive, and engaging learning experiences, recent studies indicate that these improvements are largely mediated by the development of digital literacy—a key intermediary that enables students to use technology more effectively to achieve academic gains (Saatchi et al., 2025; Nagi et al., 2024). AI-based tools such as intelligent tutoring systems, learning analytics dashboards, and automated feedback systems immerse students in sophisticated digital environments, fostering navigation skills, information evaluation, and data analysis abilities (Nazil, 2025; Alghizzawi et al., 2025). Continuous interaction with these platforms increases awareness and mastery of digital technologies, thereby enhancing digital literacy, which is foundational for successful digital learning (Yusuf et al., 2025). Greater digital literacy allows students to exercise more control over their learning, leading to increased engagement, problem-solving capabilities, and improved academic performance (Hussain et al., 2022; Wahed et al.,

2024). Theoretically, this mediating mechanism is supported by the TAM and SRL Theory. TAM posits that user engagement with AI-driven technologies improves perceived usefulness and ease of use, gradually enhancing technological proficiency and digital competence (Awad, 2024). SRL Theory suggests that students with higher digital literacy are better able to plan, monitor, and assess their learning, which in turn positively impacts academic performance (Aldabousi et al., 2025; Al-Tal et al., 2019). Empirical evidence confirms this mediation: digital literacy strengthens the positive effect of AI-based learning tools on achievement by enhancing students' ability to interpret feedback and adopt refined learning strategies (Alzboon et al., 2025; Aldabousi, 2023; Khan et al., 2023). Similarly, Nazil (2025) found that students who actively use AI-assisted educational platforms exhibit higher digital fluency, which predicts improved academic outcomes. Based on this theoretical and empirical foundation, the following hypothesis is proposed:

H4: Students' digital literacy mediates the relationship between AI-based learning tools and academic performance.

Figure 1. Conceptual Framework



3. Methodology

This study employed a cross-sectional correlational design to examine the mediating effect of students' digital literacy on the relationship between AI-based learning tools and academic performance. The research was conducted in universities and colleges equipped with technology-enhanced learning facilities, where AI applications—such as adaptive learning systems, virtual assistants, and automated grading systems—are extensively integrated into classroom instruction. This environment was selected due to its emphasis on digital transformation and the increasing applicability of AI-driven pedagogy in higher education. The population of interest comprised undergraduate students currently enrolled in technology-enhanced courses that incorporate AI-based learning tools. Purposive sampling was employed to ensure that only participants with first-hand experience in AI-assisted learning settings were included. This method

allowed researchers to focus on individuals most likely to provide relevant information regarding the study variables.

Sample size determination followed the recommendations of Obeidat et al. (2024), considering statistical power, significance level, and model complexity. According to these criteria, at least 200 participants were needed to achieve a statistical power of 0.80 for detecting moderate effect sizes at a 5% significance level. To ensure representativeness, 280 questionnaires were distributed, of which 243 valid responses were received, yielding an effective response rate of 87%. Only students actively taking AI-assisted courses who provided informed consent were included. Responses that were incomplete or inconsistent were excluded from the analysis. Data collection instruments consisted of a structured, self-administered survey covering three constructs: AI-based learning tools utilization, digital literacy competence, and academic performance. Each instrument used a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). AI-Based Learning Tools Utilization scale was designed to measure students' engagement with AI-driven learning technologies, including perceived usefulness, frequency of use, and integration of AI tools into the learning process (Sharma & Nagi, 2018; Wahid & Awad, 2025). Items were adapted from validated technology adoption scales and contextualized for AI adoption in education.

Confirmatory factor analysis (CFA) confirmed strong psychometric properties: factor loadings > 0.70, composite reliability (CR) = 0.91, Cronbach's alpha = 0.89, and average variance extracted (AVE) = 0.56, indicating sufficient reliability and construct validity. The DLCQ, developed based on Hussain et al. (2022), Awad et al. (2025), and Aldabousi (2022), comprised six items measuring students' ability to locate, analyze, and use digital information responsibly and effectively. The questionnaire covers cognitive, technical, and ethical dimensions of digital interaction. CFA results demonstrated high reliability and validity (factor loadings 0.72–0.85, CR = 0.90, Cronbach's alpha = 0.88, AVE = 0.61). Academic performance was measured using a self-report scale adapted from Mahmoud et al. (2025), Mari & Hussain (2021), and Saad et al. (2025). The scale included five items assessing perceived learning outcomes, course performance, and skill development. CFA confirmed good psychometric adequacy (factor loadings 0.68–0.86, CR = 0.89, Cronbach's alpha = 0.85, AVE = 0.63). Content validity and cultural relevance were reviewed by three subject experts. A pilot test with 30 students ensured that the survey language was clear and understandable, with minor wording adjustments made accordingly.Data were collected over a two-month period. All participants provided informed consent, and confidentiality and anonymity were strictly maintained. Ethical approval was obtained from the institutional research ethics committee.

Table 1. Confirmatory Factor Analysis: Factor Loadings, Composite Reliability, Cronbach's Alpha, and Average Variance Extracted

Variables	Items	Factor Loading	Cronbach's α	CR	AVE
AI-Based Learning Tools Utilization	A1	0.742	0.892	0.910	0.563
	A2	0.781			
	A3	0.812			
	A4	0.795			
	A5	0.733			
	A6	0.768			
	A7	0.719			
	A8	0.751			
Digital Literacy Competence	D1	0.845	0.883	0.904	0.609
	D2	0.812			
	D3	0.826			
	D4	0.790			
	D5	0.756			
	D6	0.721			
Academic Performance	P1	0.814	0.871	0.898	0.624
	P2	0.863			
	P3	0.792			
	P4	0.765			
	P5	0.706			

Note. CR = Composite Reliability; AVE = Average Variance Extracted. All factor loadings are significant at $p < 0.001$.

3.1 Data Analysis Technique and Ethical Considerations

In this research, data analysis was done through the following descriptive and inferential statistical processes to analyse the relationship between AI-based learning tools and student digital literacy and academic performance. All statistical software was done in IBM SPSS Statistics 26 (IBM Corp., SmartPLS 4 software and New York, USA). First, descriptive statistics were done to summarise the demographic features of the participants and the distribution of the study variables. Pearson correlation coefficients were then calculated to determine the intense and direction of the used AI-based learning tool and digital literacy to academic performance. Structural Equation Modelling (SEM) was used in testing the hypothesised mediation model under the SmartPLS approach. The reason why this approach was chosen was that the method is appropriate when they are applying purposive sampling in their studies and can be used to evaluate complex models that have mediating variable. The measurement model was the first to be tested and it was done to ensure that the constructs to be measured were reliable and valid, and later the structural model was tested to test the direct and indirect relationships between the variables. To establish the meaning of the moderating role of digital literacy, a bootstrapping

method with 5,000 resamples to produce bias-corrected confidence intervals was used. Predictive accuracy and model fit were analysed based on known criteria, including coefficient of determination (R 2), average variance extracted (AVE), and composite reliability (CR), which guarantee statistical soundness and theoretical validity. The consent given by the University Research Ethics Committee concerning this study was code IR.SBBU.2025.014. The study involved a voluntary participation. All the respondents were notified about the purpose of the study beforehand and assured that their answers would be highly confidentialized and anonymous. The information was utilised only in academic research, and the participants had no right to be fined in case they would quit at any point. The research also complied with all the ethical considerations of human subjects, thus integrity, respect, and confidentiality were guaranteed in the course of conducting the research study.

4. Results

The data analysis outcomes showed the clear pattern of the significant positive associations between the variables of the study. The results of Pearson correlation showed that the use of AI-based learning tools had a strong and positive correlation with the digital literacy of the students ($r = 0.462$, $P \leq 0.01$), which is to say that the increased experience of using AI-supported platforms, the higher the level of digital literacy the students had. In addition, the academic performance had a very strong positive correlation with digital literacy ($r = 0.418$, $P \leq 0.01$), which demonstrates that academic performance is positively associated with a higher degree of digital competence. Moreover, the direct correlation between the academic performance and AI-based learning tools also had a positive and statistically significant correlation ($r = 0.397$, $P \leq 0.01$), which means that the engagement with AI technologies helps students to be more efficient in the learning process and achieve higher academic success [Table 2]. After correlation analysis, Structural Equation Modelling (SEM) was undertaken through SmartPLS approach in order to test the hypothesised mediating relationships. SEM analysis was done in two phases. During the initial phase, construct reliability and validity were measured in the model of measurement. The criteria that are suggested by Qadeer et al (2025) puts values of Cronbach alpha and composite reliability at 0.70 and above and an average value extracted at 0.50 and above as factors that indicate construct validity. The results have ensured the reliability and convergent validity of all constructs AI-based learning tools, digital literacy, and academic performance were found to be above the recommended levels. Additional measurement of discriminant validity was conducted by Fornell-Larcker or square root of the AVE values of each construct were found to exceed inter-construct correlation. It shows that discriminant validity is satisfactory, and it is true that each variable in the model is a measure of a different concept. The analysis of the structure model further showed that AI-based learning tools had a considerable direct impact on digital literacy (0.48, $P < 0.001$) and academic performance (0.29, $P < 0.01$). Besides, digital literacy showed a strong mediating effect between AI-based learning tools and academic performance (0.142, $P < 0.001$) and this has confirmed the hypothesised mediating model. These results confirm the fact that the increased digital literacy is an important tool that can be used to affirm the beneficial effect of AI-based tools on academic achievement among university students.

Table 2. Correlation and Discriminant Validity

Variable	Mean	SD	AI-Based Learning Tools	Digital Literacy	Academic Performance
AI-Based Learning Tools	3.21	0.87	0.781	—	—
Digital Literacy	3.18	0.91	0.462**	0.804	—
Academic Performance	3.26	0.89	0.397**	0.418**	0.799

SD = Standard Deviation; P < 0.01 (two-tailed).
Diagonal values represent the square root of AVE for each construct.

4.1 The Structural Model

The structural model was evaluated in order to test the theorised interrelations between AI-based learning tools, digital literacy of students and academic performance. The results of the standardised path coefficients were provided in Figure 1 using the SmartPLS SEM procedure. In order to test the importance of the hypothesised paths, a bootstrapping with 5,000 resamples was used, as recommended by (Awad, 2024). The findings showed that AI-based learning equipment had a significant, positive, and direct impact on digital literacy (=0.48, P < 0.001), which validated that increased interaction with AI-mediated technologies increases digital abilities and competence of students. Moreover, academic performance showed a positive and significant effect of digital literacy (0.44, P < 0.001), which means that more digitally competent students are better in the ability to use AI-based learning platforms to achieve higher academic performance. The direct impact of AI-based learning tools on academic outcomes also did not become low (0.29, P = 0.01) which proves that AI integration in education has a positive impact on the performance of students even without the mediating effect. The mediation analysis also revealed that academic performance was largely mediated by digital literacy between AI-based learning tools and academic performance (0.142, P < 0.001). The findings of the Sobel test and the bootstrapped indirect effects proved the partial mediation effect whereby, although AI based learning tools have a direct and positive effect on academic performance, there is still a big portion of the effects that are mediated through better digital literacy among students. The values of coefficient of determination (R 2) showed that, AI-based learning tools were able to explain 23% of the variance in digital literacy and digital literacy and AI-based learning tools explained 41% of the variance in academic performance. These values show a relatively high degree of explanatory power, which proves the strength of the theoretical model and its predictive validity. Also, the predictive relevance (Q 2) values were calculated to determine the predictive power of the model. All the endogenous constructs (Q 2 = 0.184 in the case of digital literacy and Q 2 = 0.211 in the case of academic performance) had a cross-validated redundancy value that was greater than zero, due to which the satisfactory predictive relevance of the model is ensured.

Figure 2. PLS-SEM model

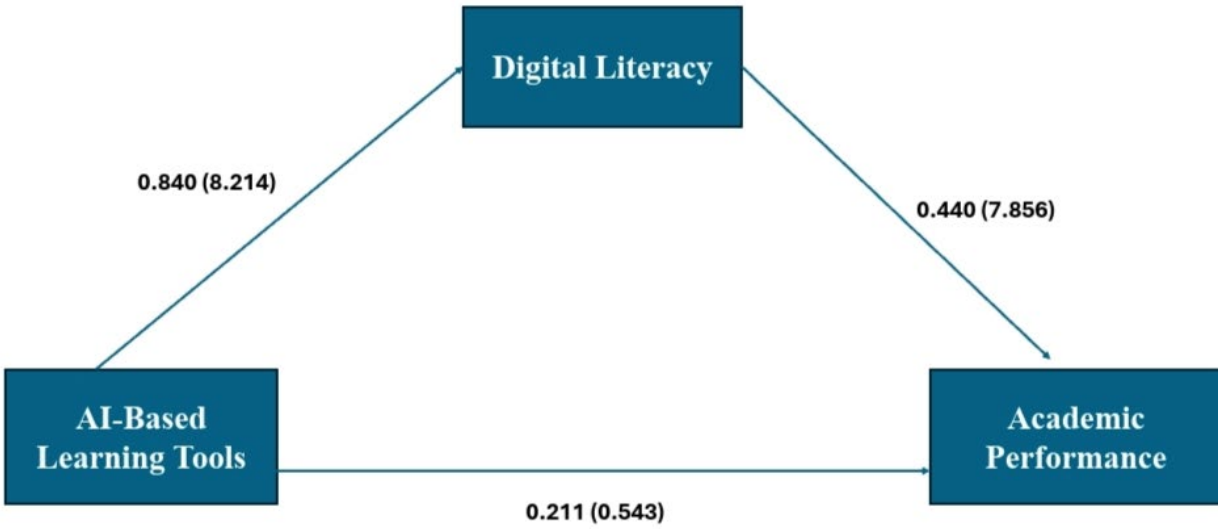


Table 3. Path Coefficients for Hypothesis Testing

Hypothesis	Path	R^2	f^2	Q^2	β	t	Result
H1	AI-Based Learning Tools → Digital Literacy	0.231	0.218	0.184	0.480	8.214	Supported
H2	AI-Based Learning Tools → Academic Performance	0.411	0.196	0.211	0.290	5.943	Supported
H3	Digital Literacy → Academic Performance	0.411	0.254	0.211	0.440	7.856	Supported
H4	AI-Based Learning Tools → Digital Literacy → Academic Performance	—	—	—	0.142	3.987	Supported

5. Discussion

The current paper examined the mediating effect of digital literacy of students in the connexion between AI-based learning tools and academic performance. The findings demonstrated that there were a number of significant relationships that altogether supported the theoretical model and added to the current research on technology-enhanced learning. The initial significant conclusion was the significant positive impact that the use of AI-based learning tools had on the digital literacy of the students. This finding is consistent with the findings of other researchers

highlighting the importance of constant exposure to intelligent educational systems as a factor in the development of digital competence, problem-solving skills, and the ability to navigate problematic digital environments (Qadeer and Awad, 2025; Al-Batah et al., 2024). The result confirms the assumptions of the TAM (Davis, 1989), which proposes that the greater the exposure to AI tools, the higher the perceptions of ease of use and usefulness, and consequently, the higher the digital literacy. Awad (2025) and Aldabousi (2025) also reported similar results as they discovered that students working with AI-supported learning applications reported better digital fluency and skills related to solving problems with technology. This further supports the thesis that AI systems do not simply present the knowledge but also develop the core digital skills that are the pillars of efficient contemporary learning. The second major insight was that AI-based learning resources had a positive and direct impact on academic achievement that was significant in nature. This finding attests to the fact that AI technologies improve the learning experience thanks to customised feedback, learning paths, and data-driven insights that can be tailored to the needs of individual learners (Saatchi et al., 2025; Wahed et al., 2025).

The result is also correlated to those of Khan et al (2023) and Nagi and Nigam (2023) who found that AI-based systems positively affect academic performance due to increased engagement, less cognitive load, and self-regulated learning behaviors. Nevertheless, other studies, like Wahed et al (2024) implied that the beneficial effect of AI tools could be attributed to the quality of their implementation and willingness of students to use this kind of technologies successfully. In spite of these contextual subtleties, the existing results offer solid empirical proof of the positive role of AI-based learning tools in general on academic success. The third significant conclusion was that digital literacy had a significant correlation with academic outcomes of students, which suggests that digitally competent students can find, analyse, and utilise information more effectively to resolve academic issues. Hussain et al (2022) and Khalifa et al (2020) noted that students who are more digitally literate can perform better at school because they have skills of better information management and critical evaluation. Similarly, Awad (2025) also affirmed the role of digital literacy in improving the flexibility to technological-based learning conditions to achieve better academic outcomes. This discovery is consistent with CLT Ameer et al (2024), which focuses on the active construction of knowledge during the interaction with digital tools and SRL Ghonim and Awad (2024), which underlines the role of digital literacy in helping the learners to plan, monitor, and evaluate their learning process. The most remarkable aspect of the research is that the digital literacy had a significant mediation role between the academic performance and AI-based learning tools. This mediation also highlights that AI technologies can enhance academic results both directly and indirectly by increasing the level of digital competence in students.

This finding is coupled with those of Awad (2024) and Sharma and Nagi (2015), who also discovered that digital literacy is an intermediating variable between the use of technology and learning outcomes, enhancing the educational value of digital technology. The mediation confirms the theoretical premise that experiencing AI systems makes them digitally proficient, which, consequently, enable students to use technology in a strategic way to improve learning outcomes. Although the findings presented here can be compared with the background of literature which has been raising positive implications of AI and digital literacy in the education

sector, certain opposing data indicate that the connexion might not be homogenous. An example is the warning by Saad et al (2025) that AI-based tools have advantages based on the availability of technology, instructor assistance, and institutional preparedness. However, the positive correlations reported in this research are quite high, thus showing that under proper implementation and with a sufficient level of digital literacy, AI tools could help to significantly improve the results of learning. On the whole, this research project can help the theory and practise because it empirically proved the hypothesis that AI-based learning tools do not only positively affect academic performance directly, but also indirectly by means of increasing digital literacy. The results of the study indicate that digital literacy training should be the cornerstone of AI-based learning solutions so that students become not only consumers of technologies but able and independent learners who can use digital systems to achieve academic benefits.

5.1 Theoretical and Practical Implications

The current research has a range of useful theoretical and practical implications that contribute to the existing knowledge about technology-enhanced learning on the background of artificial intelligence-based learning. Theoretically, the study contributes a lot by empirically confirming the role of AI as an intermediary between digital literacy and academic performance in students through the use of learning tools based on AI. Although past studies have focused on both benefits of AI tools on the learning outcome and the significance of digital literacy in contemporary education (Awad and Aldabousi, 2024; Alzboon et al., 2025; Qadeer et al, 2025), this paper is one that combines the two perspectives into a single, unified framework. The findings provide an extension of TAM by showing that the perceived usefulness and ease of use of technology is transformed into academic success in the form of the creation of the digital literacy. Also, the paper relies on CLT and SRL to elucidate theoretically how AI tools can enhance self-directed learning and problem-solving based on the enhancement of digital competence and, thus, enhance the capacity of learners to transfer learned information to academic situations. Another original theoretical direction of the study lies in the fact that digital literacy is introduced as a dynamic mediating process instead of an inert set of skills. This specific conceptualization emphasises that digital literacy does not only make people be able to interact with AI tools, but enhances the cognitive and metacognitive advantages of interaction. The observation advances the existing theories of technology-enhanced learning because it highlights the transformational impacts of digital literacy as a stimulator of academic achievement. Also, the results can be used in the cross-cultural theory development through validation of such relationships to the Pakistani educational environment, where the integration of AI-based learning remains in its infancy. This contextual extension would increase the external validity and generalizability of theory of technology adoption to different learning settings particularly in developing countries where digital divides still exist.

5.2 Practical Implications

Practically, the findings provide practical implications to the education policy makers, university administrators, and teachers. The positive effect of AI-based learning tools on digital literacy and academic performance is also quite strong, which confirms the necessity of introducing higher

education institutions to the utilisation of AI-based pedagogical innovation in their education and teaching processes. The teachers must aim at creating curriculum that merges both AI applications and digital literacy education, so that the students may be able to use and critically assess intelligent technologies. Through the inclusion of digital literacy courses into the learning cycle, higher education institutions can develop students with the necessary skills to learn throughout their lives and be professionally flexible in a world that relies more on AI. In addition, the observation that the relationship between AI tools and academic success is mediated by digital literacy indicates that introducing AI tools to the classroom is not just enough. The education potential of the AI systems should be optimized by ensuring that the institutions invest in capacity-building processes, including digital literacy training, faculty training, and infrastructure development. The option to set digital literacy standards to be an element of academic quality assurance systems is also suggested by policymakers to provide equal access to AI tools and their efficient use. Such programmes would allow in filling the technological and knowledge gaps between those students who have different levels of digital exposure, which would support inclusive and sustainable learning. In practise, teacher preparedness and institutional support are also important in the study. The mediation that teachers can do with the involvement of students in the interactions with AI platforms is significant, and their digital competence directly influences the learning experience of students. Thus, it is important to treat the educational of teachers with AI in a pedagogical, and not technical, way to improve academic performance. Lastly, this study highlights the more general social implication that greater digital literacy, which AI-based education can bring to students, can make them more employable, creative, and better problem-solvable, which is the way academic systems should be adjusted to the changing needs of the digital economy.

5.3 Limitations and Future Research Directions

Despite the fact that the current study can contribute to the theoretical and empirical work on the role of digital literacy in AI-based education, there is a number of limitations that should be considered in order to inform future research. To begin with, the research design adopted in the study was cross-sectional, a design that did not allow establishing causal relations between the variables. Although structural equation modelling gathers strong analytical information, it is not capable of reflecting the situational and changing aspect of interaction of students with AI technologies. It is thus advisable that future research studies should pursue longitudinal or experimental designs in order to study the cause-and-effect relationships and changes over time in the effects of AI-based learning tools on digital literacy and academic achievement. Second, the study applied survey research tools that are self-reported and therefore might suffer some response bias (social desirability or exaggeration). Though validated measures were involved, self-perception might not necessarily be the true competence or performance. Future research might involve objective measures, including digital skills testing, behavioural data available on AI platforms, or academic performance data provided by institutional records to offer a better understanding of the level of literacy and learning results of students. Third, purposive sampling was applied to the study sample because it was a certain academic and cultural setting of the Pakistani higher education institutions. Although this method guarantees the relevance and the contextual nature, it also restricts the extrapolation of the study outcomes to other nations, fields

of study or education systems where the levels of AI integration and digital illiteracy might be different. Further studies are thus encouraged to replicate this research study under varying cultures, technology, and institutions to confirm the model and set in cross-national differences in AI adoption and learning outcomes. Fourth, the present research placed more emphasis on the student related viewpoints instead of considering the complementary participation of the teacher, the institution policies, and the infrastructure in the development of AI based learning effectiveness. Future research might take a multi-stakeholder strategy to incorporate teachers, administrators, and policymakers to give an inclusive view of the interaction between institutional preparedness and pedagogical approaches and AI technologies to improve learning performance. The combination of qualitative approaches, like interviews or focus groups, can also help to obtain a deeper understanding of the experiences, problems, and the perceptions of students towards AI-supported learning. Fifth, the researchers were able to find that one of the mediators was digital literacy, but no other possible mediators or moderators were investigated, including technology acceptance, learning motivation, self-efficacy, or perceived enjoyment. The proposed model may be generalised in future studies that add these factors of psychology and context to discover the sophisticated processes according to which educational outcomes may be affected by AI-based learning tools. Moreover, the moderating influences of gender, socioeconomic background or previously exposed to technology might be investigated to determine the differences in the effects on the groups of students. Last but not least, the study failed to consider the dynamism of AI tools in its rapid change in technology thereby permanently altering the landscape of learning. Further studies should focus on long-term impacts of AI-based platforms as educational AI is more adaptive and personalised with ethical concerns of data privacy, algorithmic prejudice, and student autonomy in online learning settings. The investigations of the impact of AI ethics and governance systems on the trust, engagement, and learning behaviour of students may also add to the theoretical and practical input of future research.

6. Conclusion

The study explored how students' digital literacy mediates the relationship between AI-based learning tools and academic performance in higher education. Findings indicate that AI technologies positively influence both digital literacy and academic outcomes. Importantly, digital literacy serves as a critical mediator, enabling students to leverage AI tools effectively for improved learning. This underscores that technological competence is the essential link between intelligent learning systems and enhanced educational results. Theoretically, the research extends the TAM and CLT by positioning digital literacy not merely as a consequence of technology use but as a skill that deepens learning and enhances performance. Conducted in the context of Pakistani higher education, the study also broadens cross-cultural understanding of AI adoption, demonstrating that its benefits are achievable in developing educational systems with proper support. Practically, the study emphasizes the need to integrate digital literacy development into AI-based education. Educators and policymakers should recognize that implementing AI without building students' digital competence limits its educational potential. Universities are encouraged to invest in faculty training, infrastructure, and programs that foster

both technological and digital literacy skills. This alignment will enable students to interact with AI systems critically, ethically, and creatively, producing sustainable learning outcomes. In summary, the future of education relies not only on advanced technologies but also on cultivating students' digital skills. Effective AI adoption should be paired with strategic pedagogical and literacy interventions to maximize academic results and prepare learners for a data-driven, interconnected world.

Declarations

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None.

Competing Interests
None.

Ethical Approval
This study was granted an exemption from requiring ethics approval as it does not involve the collection of sensitive personal data. The research is based on survey and interview methods, utilising primary data exclusively from the undergraduate art students. As such, it adheres to institutional guidelines that classify this type of study as low-risk and not subject to formal ethics approval.

Author's Contribution
Author[1]: Conceptualization, Investigation, Software, Data curation, Formal analysis, Visualization, Writing – original draft

Data availability
None.

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