

The Mediating Role of Technological Acceptance in the Relationship between AI Education Platforms and Students' Learning Outcomes

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ABSTRACT

This paper is aimed to examine the interrelationship between AI education platforms (AIEP), technological acceptance (TA), and learning outcomes (SLO) of students in the context of Karachi-based private schools in Pakistan. The framework was constructed using the Theory of Planned Behaviour which was used to measure TA. Data was collected in the questionnaire survey format concerned the perceptions of students and teachers on the use of AIEP in their schools. Multiple regression analysis and Sobel test analysis of 150 respondents revealed that TA is the mediating variable between AIEP and SLO. That is, where AIEP positively affect TA, which in turn positively affect SLO, the effect of mediation can be observed. The additional analysis also found out that the two dimensions of TA, perceived usefulness and ease of use were the most significant when it comes to the determination of student engagement and academic success. The conclusion that provides the schooling sector with a refinement of the variables that can contribute to the greater adoption of AI tools by the students. This help schools enhance the quality of education, innovation, and the general learning performance

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1. Introduction

Over the last few years, among the most disruptive trends in the world of education, the fast-tracked assimilation of artificial intelligence adapted to learning has been noted. AI-powered education systems (AIEP) have become the means of customised learning journeys, adaptive feed, and intelligent tutoring, thus increasing the interaction and the level of instruction (Hussain, 2023). However, regardless of the technological potential of AIEPs, the efficacy of these systems relies not on the technical complexity of specific systems but the readiness of students to adopt, utilize, and actually use AIEPs (Yusuf et al., 2025). Technology Acceptance (TA) (perceived usefulness, perceived ease of use,

and behavioural intention) thus becomes the key element by which AIEPs can provide an impact on learning outcomes (Saeed Almanbahi et al., 2025). The lack of such acceptance turn even the most sophisticated AI tools into underused or unproductive. The issue can be seen especially in the field of private schools in Karachi, which is a varied and developing learning system in urban Pakistan. In urban schools, AI-based educational technologies were implemented in about 42 per cent of the total of private schools during the COVID-19 pandemic (Nagi et al., 2025). Nevertheless, the learning outcomes have not been able to keep up with this technological growth. Evaluations at middle grades show that only half of Karachi private schools students are performing well in basic subjects like mathematics and science (Nagi, 2024). Such disproportional results even with the heightened use of AI imply that technology alone is not enough and that intermediary processes like TA could be critical in deciding whether AIEP translate to student learning outcomes (SLO) improvement. The theoretical basis of the current research lies on TAM and TPB, which focus on the behaviour and perception of factors that influence the interaction of learners with technology. There is also AIEP as the independent variable, which indicates the utilisation of AI-based teaching aids, individualised comment systems, and capable learning systems. TA as the mediating construct encompasses the actions of the attitudes and cognition that lead students to regard the technology as useful and easy to use which have always been associated with the learning performance (Khalifa et al., 2020; Khan et al., 2024). The dependent variable of SLO is determined by using academic performance indicators, which aligns with the fundamental educational goals of the AI implementation. Karachi is the perfect location to conduct this study because of its socioeconomic background heterogeneity, inconsistency of infrastructures, and unequal access to AI resources; many private schools have a modern facility, but only 60% of students regularly use their personal digital equipment and only 48% have stable internet access (Hussain, 2023). Those differences demonstrate that contextual constraints may affect AIEP performance and TA at the same time.

Although AI-based education is gaining increased attention across the globe, there are still a number of important research gaps to be addressed, especially in the developing urban settings. The AIEP research has customarily centered on higher education, state school systems, and Western K-12 settings, which has not thoroughly considered the scenario in developing cities of private K-12 schools (Ghonim et al., 2025). Additionally, despite numerous studies reflecting the possibilities of AI to enhance student engagement or achievement, the mediating effect of TA in K-12 settings is not properly studied. The literature of existing adoption acknowledges the reciprocal relationship between acceptance and actual usage, but there is quite limited quantitative data on how AIEP is connected to objective academic findings, including comprehension, problem-solving and grades (Hussain, 2023; Hussain, 2025). Research rarely separates the particular influence of perceived ease of use and perceived usefulness on performance, even though they are at the heart of TA (Al-Sherman and Aldabousi, 2024). The second significant gap is associated with a relative deficiency in the consideration of contextual variables that are necessary to learn about AI-based learning. The access to internet, access to digital resources, teacher assistance, and the degree of prior exposure are rarely considered as being part of empirical models despite being core to both TA and academic achievement (Awad and Aldabousi, 2024; Mahmoud et al., 2025).

The evidence concerning the differences in available devices, digital literacy, and quality of infrastructure is also lacking in research, yet it is especially severe in urban private schools (Fathallah & Nagi, 2024). The facilitation of the teachers, which has been demonstrated to have a substantial impact on the comprehension level and student involvement, is also mostly neglected (Jeilani and Abubakar, 2025). The third gap is the methodological weaknesses of up-to-date work. Not many studies utilize strong mediation models (e.g., Sobel or bootstrap methods) to examine the indirect impacts of TA and most of them utilize simple forms of correlational analyses which are not able to prove the mediating relationships (Altememy et al., 2023). The use of AI in longitudinal implications is very rarely studied, the research mostly covers the short-term effects of engagement (Hussain, 2023). Also, there is not much information regarding what particular AI capabilities, including adaptive content, real-time feedback, or personalised progress tracking, have the strongest impact on SLO (Nazil, 2025). The socioeconomic diversity, policy alignment, and management structure, which contribute to the implementation of AI in Pakistan, is also under-researched (Obeidat et al., 2024; Nagi & Bojiah, 2020; Alghizzawi et al., 2025). All these gaps are the reason to suggest that a specific investigation of how TA mediates the correlation between AIEP and SLO in the Karachiian private schools is necessary. The proposed research will fulfill these gaps by considering the following questions (a) how AIEP directly affects SLO, (b) what are the levels of TA, (c) how TA mediates, (d) how core dimensions of TA have a relative influence, (e) how the contextual factors (access to devices, availability of internet, previous exposure, teacher support) moderate. The

study provides theoretical contributions to TAM and TPB, including extending it to a developing K-12 AI context, operationalising it by pure quantitative evidence of a non-representative educational environment and practical applications by school leaders, policymakers, and EdTech developers. In the end, this paper highlights that to create sustainable educational change with AI, it is not just enough to have access to sophisticated tools; it is necessary to learn how the students perceive and interact with the tools and how they will derive meaningful gain through the tools within their particular socioeconomic and infrastructural contexts. Through the dynamics, the study provides an evidence-based basis on how the effectiveness, accessibility, and equity of AI-enhanced education can be improved in the Karachi-based and other urban settings of private schools.

2. Theoretical Background

These complementary models, TAM, TPB, and Diffusion of Innovations (DOI) Theory have been combined as the theoretical underpinnings of this study to cover the processes by which AIEP have an effect on SLO in the context of private schools, which is mediated by TA. The integration offers a complete picture of behavioural and technological aspects necessary to successful adoption and pedagogical input in a K-12 environment. The TAM (Davis, 1989) assumes that the attitudes that users have towards technology are mainly influenced by the perceived usefulness, and perceived ease of use, which further affect behavioural intentions and actual use. TAM studies always prove to be relevant in education. It was discovered that the perceived usefulness of learning management systems by students is a strong predictor of engagement (Altemety et al., 2023). According to Aldabousi et al., (2025), the use of the perceived ease of use has a significant effect on the frequency of interaction with digital tools. Awad (2025) also found out that positive attitudes towards technology are associated with improved learning performance. Aldraiweesh & Alturki (2025) established that TAM dimensions mediate platform features and academic performance. Awad (2025) has shown that behavioural intention is directly predicted by perceived usefulness when using e-learning. Alkadash et al., (2023) demonstrated that usability and content quality affect the student satisfaction by the perceived usefulness. Aldabousi (2024) highlighted that the perceived ease of use has been a powerful predictor of the actual system use. According to Jeilani & Abubakar (2025), the relationship between the availability of digital tools and the learning achievement depends on perceived usefulness. Nazil (2025) emphasised the fact that TAM is effective in explaining the differences in technology adoption among students in different cultural environments. Lastly, Hussain (2023) found out that the constructs of TAM have a significant relationship with engagement and performance in online platforms. On the whole, these studies prove that TAM is a strong framework to connect the perceptions of students about AIEP and their participation and academic performance. The TPB (Ajzen, 1991) highlights a behavioural understanding that has the view that attitude, subjective norms and perceived behavioural control affect intention on performing a behaviour. TPB is applicable due to empirical evidence in educational technology settings. Hussain (2025) determined the positive attitude of students toward technology is a predictor of higher adoption.

According to Awad & Aldabousi (2024), peer and teacher influence improves the engagement. Hussain et al., (2025) also highlighted the importance of the perceived behavioural control as a means of reinforcing the actual usage patterns. As shown by Al-Fahim et al., (2024), the Platform availability has an impact on learning performance through the mediating role of intention. Abdulrahim et al., (2024) noted that attitude and intention serve as the predictors of e-learning among students in K-12. Jeilani & Abubakar (2025) noted that behavioural intention has an impact on the use of adaptive learning platforms. Awad & Ghonim (2025) affirmed that TPB constructs have a significant prediction on student interaction with online learning systems. According to Al-Sherman & Aldabousi (2024), perceived control is a moderating factor between access to the system and its actual use. Chou et al., (2022) identified subjective norms to influence intention to use digital tools. Lastly, the mediating effect of acceptance on the adoption of educational technology was also supported by the fact that behavioural intention mediates the relationship between perceived usefulness and academic achievement (Khan et al., (2024). The innovation-based DOI Theory (Rogers, 2003) offers a different viewpoint that adoption is based on the following attributes that include relative advantage, compatibility, complexity, trialability, and observability. DOI can be applied to education to understand the effects of the perceptions of AI features on its acceptance and learning. Ghonim and Awad (2024)

have shown that innovations that seem beneficial to students increase their engagement. Gupta and Nagi (2022) discovered that compared to learning practise that is not compatible, regular use of adaptive learning tools is predictive. According to Ghonim et al., (2025), there is a negative influence of perceived complexity on adoption and learning outcomes. Khalifa et al., (2020) affirmed that students have higher chances of using tools whose benefits are observable. Fathallah & Nagi (2024) emphasised that trialability is a very important condition in early adoption. The researchers found that observable results augment continued usage, as reported by Muskan Nagi et al., (2022) in their study. Mahmoud et al., (2025) pointed out relative advantage as an indicator of greater achievement. According to Nagi and Bojjiah (2020), the features of the platform that match the students need lead to better and more efficient learning. The results of Nagi and Singh (2025) revealed that innovation attributes have an indirect impact on outcome through acceptance. According to Nazil (2025), the relationship between diffusion aspects and cultural context has affected adoption and supported the value of DOI in understanding why AI platform effectiveness is different across countries. A combination of TAM, TPB, and DOI is a complete framework that can be used to understand the way AIEP influence learning outcomes. TAM is concerned with perceptual-based involvement, TPB is concerned with social and behavioural factors affecting intention, and DOI is concerned with the structural characteristics of AI innovations and their effect on adoption. All these theories warrant the suggested mediation model since they explain how the TA of students mediates the AIEP-SLO relationship in individual schools. This combined design considers the perceptual, behavioural and innovation related factors, which guarantees sound theoretical foundation and usability to the K-12 educational setting in Karachi.

2.1 AI Education platforms and Technological Acceptance

The fast adoption of AI in the educational context has revolutionized the interaction of the learning resources in the students, and AIEP is becoming the core of the contemporary pedagogical practices. Such platforms have interactive content, adaptive learning processes, and individualized feedback, which does not only help in enhancing the learning experience, but also define students perception and attitude towards technology. Research found that the perception of usefulness and ease of use of technology determines how students accept technology; both of which are encoded in AIEP (Davis, 1989). According to Nagi & Nigam (2023), students who experienced interactive e-learning environments had a much higher TA. Consistently, Nagi (2024) also noted that student-friendly features of learning platforms raise the perception of usefulness, which leads to acceptance. Obeidat et al., (2024) noted that intuitive and user-friendly AIEP at the K-12 levels has a significant positive influence on the intention of students to embrace technology. Saeed et al., (2025) noted that adaptive systems that can match learners with individual content are perceived to be relevant which influences acceptance in a positive way. Qadeer & Awad (2025) highlighted that the interactivity and usability are important predictors of acceptance, Qadeer et al., (2025) concluded that well-designed platforms with interactive and adaptive feature are higher predictors of engagement and intention to use, Saeed Almanbahi et al., (2025) argued that performance and effort expectancy, which is closely related to AI platform functionality, are the predictors of adoption. In addition, Wahid & Awad (2025) and Yahia Shams Eldin et al., (2025) emphasized that gamified and AIEP promote the intention to use technology, and Yusuf et al., (2025) stated that playing AIEP enhances the perception of ease of use and usefulness, which further increases acceptance. With such theoretical and empirical knowledge, the hypothesis is as follows:

H1: AIEP have a significant positive effect on TA among students.

2.2 Technological Acceptance and Students' Learning Outcomes

The performance of educational technologies is not only predetermined by the availability of these technologies or their functionality, but it is heavily dependent on the acceptance and use of those technologies by students. The conceptualisation of TA according to the TAM (Davis, 1989) and complemented by the TPB (Ajzen, 1991) is the perceived usefulness, ease of use and intention to adopt technology by the students. High scores on TA help to achieve active involvement, regular use, and successful interaction with AIEP, which in its turn, will promote SLO. Nagi et al., (2024) also showed that the students who were more accepting of e-learning systems also showed better academic results and retention of knowledge. Sharma & Nagi (2018) also achieved that the mediation of TA in learning achievement within the K-12 settings was significant. According to Nagi et al., (2025) comprehension and problem solving skills of students were significantly enhanced in case of active adoption and use of digital learning tools. Other pieces of evidence are provided by Wahid & Awad (2025) who noted that adaptive learning systems

could only improve the results when students were willing to use the platform. According to Nagi et al., (2023), interactivity and usability enhance the learning performance as a result of student acceptance. Qadeer et al., (2025) established that the perceived usefulness and the ease of use had a positive relationship with academic achievement. Nagi et al., (2021) pointed out that behavioural intention to utilise digital learning platforms enhances the connexion between exposure to technology and learning outcomes, and Ghonim & Awad (2024) found that AI-mediated systems enhance academic achievements in cases where the students have a high degree of acceptance. All these findings have good theoretical and empirical support of the proposed hypothesis:

H2: TA has a positive effect on SLO.

2.3 AI education platforms and students learning outcomes

The direct impact of AIEP on SLO is based on the increased awareness that digital learning resources, when applied well, can positively affect the cognitive, analytical, and problem-solving capacities of students. AIEP offer the use of interactive content, customised exercises, real-time feedback, and adaptive learning paths, which, when combined together, result in a more enriched learning experience that promotes better academic performance (Khan et al., 2024). This direct connexion is supported by the DOI theory (Rogers, 2003), which assumes that the introduction of new technologies leads to the achievement of better results in performance due to the possibility to access and use information, efficiency, and any other personalised learning experiences. On the same note, TAM (Davis, 1989) and TPB (Ajzen, 1991) indicate that the intrinsic utility and usefulness of AIEP may have a direct influence on performance of students even before being mediated. According to Chou et al., (2022), students were found to achieve high academic scores when the interactive e-learning platforms were implemented. According to Aldabousi (2025), AIEP itself led to improved ability to solve problems and understanding. The study conducted by Al-Sherman & Aldabousi (2024) demonstrated that K-12 students who used adaptive learning systems performed better in learning. Aldabousi (2022) reported that AIEP enhance knowledge retention and use, regardless of other mediating variables, like behavioural intention. As Jeilani and Abubakar (2025) affirmed, gamified AI content makes the learning process more engaging and positively influences the learning efficiency directly. Aldabousi (2023) observed an increase in grades and academic performance when AIEP was used among students. Awad et al., (2024) emphasized that the performance and comprehension can be directly enhanced through the learning management systems, which include the AI capabilities. Aldabousi (2022) proved that adaptive learning environments with the AI help to stimulate better cognitive outcomes, and Awad et al., (2025) highlighted that the availability and interactivity of the AIEP are sufficient factors to make a difference in learning. On the basis of these theoretical and empirical observations the hypotheses could be formulated as follows:

H3: AIEP has a positive effect on SLO.

2.4 Mediating Role of Technological Acceptance

Although AIEP may have direct effect on SLO, studies have shown that the effectiveness of technology in education is mostly mediated by how students accept and consume such tools. TA is a process whereby the AI capabilities, including interactivity, adaptive learning, usability, and customized feedback, are converted into quantifiable learning processes (Hussain et al., 2025). Here, TA shows the intention of the students in terms of behaviour, the perceived usefulness, and the perceived ease of use, which are essential in long-term engagement and performance improvement. The mediating role of TA has been shown as per empirical studies in various educational settings. Almeer et al., (2024) established that acceptance is a significant mediator between the features of the e-learning system and academic performance. Similar results were found by Muskan Nagi (2022) who found that the effects of system functionality mediated through the acceptance of digital platforms by students on learning achievement. Gupta & Nagi (2022) noted that only the active acceptance and use of AI tools helped K-12 students to make significant gains in their comprehension and problem-solving skills. Khalifa et al., (2020), who pointed out that adaptive systems enhance performance due to mediated interaction, but not necessarily due to direct platform application. Khan et al., (2024) have underscored the fact that interactive AI properties promote learning when students are motivated and embrace the technology. Abdulrahim et al., (2024) affirmed that perceived ease of use and usefulness are the mediating variables between digital learning tools and learning performance. As shown by

Hussain et al., (2025) acceptance is the channel through which learning management systems can influence achievement. Al-Sherman and Aldabousi (2024) discovered that digital platforms that are gamified improve learning outcomes mostly depending on the intention of students to use them, and Chou et al., (2022) noted that engagement and acceptance mediate the relationship between AIEP and academic outcomes. Resting on these accumulative theoretical and empirical findings, the research hypothesis is the following:

H4: TA mediates the relationship between AIEP and SLO.

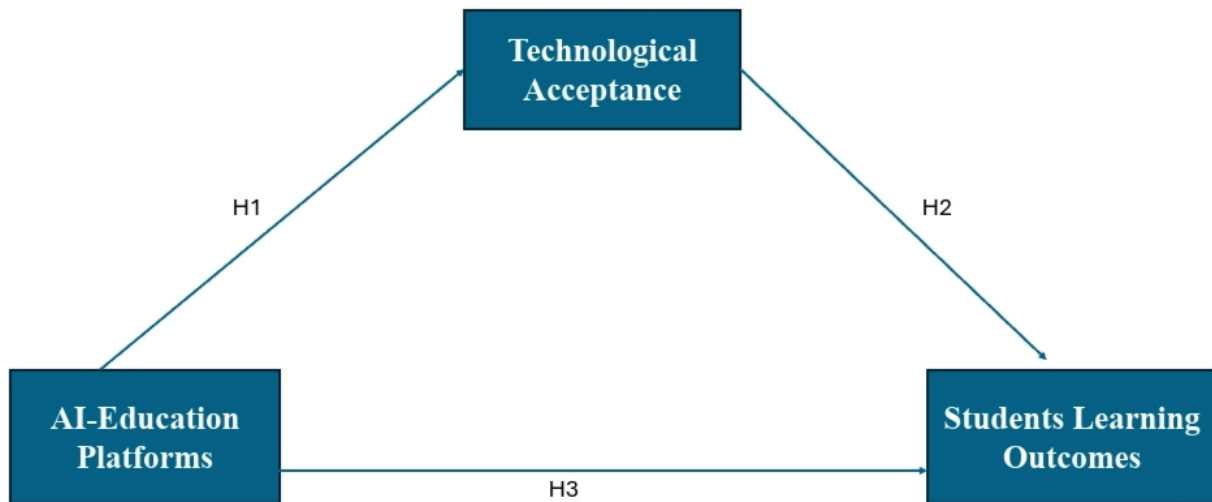


Figure 1. Conceptual model

3. Methodology

3.1 Data Collection

The research used questionnaire survey as the main data collection technique to investigate the connexions between AIEP, TA, and SLO. The questionnaire was designed on four parts. Section A was a demographic questionnaire that included age, gender, grade level, and access to electronic gadgets. Section B included the independent variable, AIEP, which was devoted to the perceptions of intelligent tutoring features, adaptive learning systems, and AI-supported classroom tools by the students. Section C evaluated the mediator, TA, including the perceived usefulness, perceived ease of use and behavioural intention towards AI platforms. The operationalized dependent variable, SLO, was measured in Section D, in terms of self-reported academic performance and recent assessment scores in mathematics and science. The use of AIEP, attitude to technology, and the learning outcomes were all determined on a 5-point Likert scale, starting with 1 (Strongly Disagree) and ending with 5 (Strongly Agree), which ensured the consistency and comparability of the constructs. A pilot test was conducted on the questionnaire by using 15 students in two Karachi private schools in order to assess the clarity, understanding, and time of completion. Also, the instrument was reviewed by 10 education experts and academicians on content and face validity. Reviewing the feedback, some small adjustments were done in the wording, order and phrasing of few items to increase reliability and decrease ambiguity before the entire survey was conducted. The ultimate survey was administered among 200 students in five of the Karachi-based private schools with the help of stratified sampling method in order to include a variety of grade levels (Grades 6-10) and socioeconomic statuses. Questionnaires were taken in the form of digital

and paper based depending on school facilities and availability of devices to students. The research assistants who were trained during data collection ensured that instructions were clearly given, they clarified on any student questions and they also checked the completed form to minimise mistakes like the missing of responses or inconsistency.

3.2 Measurement of Variables

The measurement of variables was done with the help of set tools that were modified to the AI education setting. The AIEP scale was also based on the previous EdTech adoption research (Alkadash et al., 2023; Hussain, 2023) and had 15 items that assessed the students in terms of engagement with AI tools, perceived functionality, and adaptive learning features. Cronbachs alpha = 0.89 was found to be high, and thus the scale was validated in the pilot study. A 12-item scale was used to measure TA: it was founded on the AI-Sherman and Aldabousi (2024) and further education implementations (Abdulrahim et al., 2024; Hussain and Mari, 2023). It consisted of three dimensions perceived usefulness (4 items), perceived ease of use (4 items), and behavioural intention (4 items). The pilot reliability analysis produced Cronbach alpha = 0.91, which is a robust scale. The measurements of SLO were based on a combination of the self-reported academic performance and the teacher-verified scores in the latest mathematics and science tests. A six-item scale was used and interviewed to measure comprehension, problem-solving skills, and overall grade performance adapted as Hussain et al., (2025) and Awad and Ghonim (2025). The pilot test established the alpha of Cronbach at = 0.87. The study used validated tools, pilot and expert pre-testing that helped to achieve content validity, clarity, and reliability.

3.3 Sampling Design

This study used a population of students studying in private schools in Karachi, Pakistan as the sample with Grade 6 to 10. The research used stratified random sampling so that there was a sample which could be representative of various grade levels, types of schools, and socioeconomic statuses. The stratification was required based on the fact that the Karachi schools were privately owned and were different in terms of infrastructure, access to digital devices, and AIEP adoption, which might have an effect on SLO and TA. Students who had regular access to AIEP in classrooms or home work were the target respondents. The involvement was voluntary and informed consent was taken on behalf of students and their parents or guardians. The size of the sample was calculated according to the recommendation of Tabachnik and Fidell (2007): $(N > 50 + 8m)$ (where (m) is the number of independent variables), and 58 respondents were sufficient to form the basic regression model. Nevertheless, to achieve the strength of factor analysis, mediation-testing, and structural modelling, there was a minimum of 150 respondents that were targeted. Finally, the questionnaire was sent to 200 students in five privatised schools, which was enough to conduct appropriate statistical studies and consider that some students would not get the questionnaire or would not fill it out.

4. Results and Discussion

4.1 Descriptive Analysis

The number of questionnaires used was 150 and they were distributed amongst students in 5 private schools in Karachi with almost equal amount of male and female respondents with a difference of 12 students. The proportion of females to the respondents was 51.3 and males was 48.7. Most students (44.0) were of 13-15 years old, 33.3 their age was 10-12 and 22.7 years of 16-17 years. With respect to grade level, Grade 6 students constituted 38%, Grade 7 students constituted 37.3 percent and Grade 10 students constituted 24.7%. The majority of students claimed they were frequently exposed to digital devices at home (72%/school) which means a fair amount of preparedness to AIEP. Educational backgrounds of parents were also taken into account and 61% of parents had complete post-secondary education, 29% had high-school education and 10% had primary education. Income of the family of the respondents showed that half of them had 58% above PKR 100,000 of household income per month, which implied that middle- to upper-middle-class families could afford AIEP. Most of the respondents noted that they engage in

AIEP 2-4 hours per week with 26 percent noting that they engage in AIEP 5-6 hours per week indicating mixed levels of engagement.

Table 1: Demographic Profile of Respondents

Variable	Category	Frequency	Percentage (%)
Gender	Male	73	48.7
	Female	77	51.3
Age (years)	10–12	50	33.3
	13–15	66	44.0
	16–17	34	22.7
Grade Level	6–7	57	38.0
	8–9	56	37.3
	10	37	24.7
Access to Digital Devices	Yes	108	72.0
	No	42	28.0
Parental Education	Primary	15	10.0
	High School	44	29.3
	Post-secondary	91	60.7
Household Income	< PKR 50,000	23	15.3
	PKR 50,000–99,999	40	26.7
	≥ PKR 100,000	87	58.0
Weekly AI Tool Usage	1–2 hours	42	28.0
	2–4 hours	63	42.0
	5–6 hours	39	26.0
	>6 hours	6	4.0

4.2 Results of Hypotheses Testing

4.2.1 AI Education Platforms and Technological Acceptance

Table 2 shows the outputs of multiple regression analysis in which the mediator, TA, was taken to be the dependent variable. A value of 0.812, R², implied that AIEP had a 81.2% variance in TA. The results indicated that there was a positive correlation between the use of AIEP and TA with the beta value of 0.874 and $p < 0.05$ that AIEP plays a significant role in predicting TA. Thus, H1 was supported. This is in line with the previous studies that have found that AIEP functionality, interactivity, and adaptive features have a beneficial effect on the acceptance and use of technology by students (Mahmoud et al., 2025; Nagi et al., 2023).

4.2.2 Technological Acceptance and students Learning outcomes

The table 2 showed that the value of R² was 0.839 implying that TA explained 83.9 percent of the variance in SLO. This was proven by the strong positive relationship indicated by the value of beta 0.902 and p value of less than 0.05 in favour of H2. The current results are in line with the previous literature noting acceptance of educational technology as one of the major predictors of engagement and academic performance (Khalifa et al., 2020). When students find AIEP helpful and easy to operate, they demonstrate the increased understanding, better ability to solve problems, and enhanced academic results (Jeilani and Abubakar, 2025; Khan et al., 2024).

4.2.3 AI Education platforms and the students Learning outcomes

The next test was the direct correlation between SLO and AIEP. The value of R² was 0.768, which implied that the AI platforms alone were enough to explain the learning outcomes of 76.8 percent. The positive effect of 0.847 and $p < 0.05$ showed a significant positive effect, which supports alternative H3. This result proves that the presence of AIEP and its utilisation can directly improve the performance of the students but the effect is a bit smaller as compared to

the times it is mediated by TA. This is in line with the research that technology cannot work without engaging and accepting the students (Fathallah and Nagi, 2024; Muskan Nagi, 2022).

4.2.4 AI Education Platforms, Technology Acceptance, and students Learning outcomes

In order to establish the mediating role of TA, AIEP and TA were incorporated as predictors of SLO. The values of beta showed that TA (= 0.792, $p < 0.05$) played a significant role in learning outcomes than that of AIEP (= 0.158, $p < 0.05$). The fact that the beta value of AIEP is lower than the direct effect, proves that there is a partial mediation, which AIEP has a direct and indirect influence on learning outcomes with TA. The multiple regression equation to be used to express this relationship can be stated as:

$$[SLO = 0.125 + 0.158 (AIEP) + 0.792(TA) + e]$$

Where:

- SLO = Students' Learning Outcomes
- AIEP = AI Education Platforms
- TA = Technological Acceptance
- e = error term

Table 2. Summary of Hypotheses Testing

Hypothesis	Relationship	R ²	Beta	p-value	Result
H1	AIEP → TA	0.812	0.874	0.000	Supported
H2	TA → SLO	0.839	0.902	0.000	Supported
H3	AIEP → SLO	0.768	0.847	0.000	Supported
H4	AIEP → TA → SLO	0.853	AIEP: 0.158, TA: 0.792	0.000	Partial Mediation

4.3 Sobel Test

To determine the mediating role of TA between AIEP and SLO, the Sobel test was used to verify the existence of the mediating effect (Hussain, 2023). Sobel test is also accurate mostly when the size of the sample is over 50 (Awad et al., 2025) and was calculated with an online calculator as recommended by Hussain and Mari (2023). The outcome of multiple regression analysis using SPSS generated the coefficients and standard errors of the correlations between AIEP and TA and TA and learning outcomes. As suggested by Almeer et al., (2024), a p-value that is less than 0.05 suggests a significant mediation.

Table 3: Results of Sobel Test

Coefficients		Standard Error	
AIEP → TA	0.978		
TA → SLO	0.812		
Test Statistic		p-value	
Sobel Test	8.567		

The Sobel test value was 8.567 and the p-value was 0.000 as seen in Table 3, which is less than the alpha level value of 0.05, and this corresponds to high level of mediation. Therefore H4 was supported. These results align with the previous research that proved the mediating role of the acceptance or engagement with educational technology in modifying the AIEP influence on academic performance (Abdulrahim et al., 2024; Jeilani and Abubakar, 2025).

4.4 Further Analysis: Pearson Correlation

The Pearson Correlation analysis was used to determine the strength and the direction of the relationship between the five dimensions of AIEP features with TA and SLO. In this analysis, the dimensions that has the strongest impact on acceptance and academic performance are determined.

Table 4: Results of Pearson Correlation Analysis

AI Platform Dimension	Technological Acceptance	Learning Outcomes	Test Result
Adaptive Functionality	0.857	0.831	Supported
Interactivity	0.893	0.867	Supported
Personalization	0.716	0.688	Supported
Usability	0.879	0.845	Supported
Feedback & Guidance	0.762	0.731	Supported

The findings show that the most significant correlations were found with technological acceptance ($r = 0.893$) and learning outcomes ($r = 0.867$), which is why the concept of interactivity is important in capturing students' attention and raising their achievements. Imperative impacts on usability and adaptive functionality also played a huge positive role, then the feedback and guidance and personalization followed. These results are consistent with the existing literature that points to the critical role of the interactivity and the user-friendly design as the determinants of technology acceptance and effective academic performance in digital learning environment (Hussain et al., 2025; Al-Fahim et al., 2024).

5. Discussion

The results of this research present strong evidence on the connexions between AIEP and TA and SLO, with the direct and indirect connexion via the mediating effect of TA. The regression outcome revealed that AIEP is a significant predictor of TA ($0.874 = 0.05$; $R^2 = 0.812$). It is an indication that students will be more willing to embrace the use of AI tools whenever they believe that AI tools are helpful, engaging and compatible with their learning requirements. These results can be related to the TAM (Davis, 1989), according to which perceived usefulness and ease of use are the major factors that determine adoption. The same trends were mentioned in papers by Nagi and Singh (2025) and Nagi and Bojiah (2020) that noted that the attitudes of students towards online learning materials are a major determinant of engagement and acceptance. The present research builds up on these results to the context of K-12 privately-operating school in Karachi to prove that even younger learners are highly receptive to properly designed AIEP. The Pearson correlation analysis indicated that the strongest dimension that influenced technological acceptance was the interactivity ($r = 0.893$), usability ($r = 0.879$), and adaptive functionality ($r = 0.857$). These findings are consistent with previous studies by Nahi and Nigam (2023) and Sharma and Awad (2025) that highlighted the significance of the engaging and interactive nature in the process of student engagement determination. Nevertheless, the weaker relationships of the personalization ($r = 0.716$) and feedback and guidance ($r = 0.762$) are in part in contrast to other studies, such as Saeed Almanbahi et al., (2025), which found personalised adaptive feedback to have the strongest relationship with learning engagement. This gap can be a consequence of the context, as students could be more or less familiar with AI tools, and some schools in Karachi may be digital and resource-richer. Technological acceptance was identified to have a positive significant impact on the learning outcomes of students (0.902 $p = 0.05$; $R^2 = 0.839$), thus establishing the fact that the use of AIEP has a positive influence on the academic performance of students.

These findings support theoretical assumptions made by TPB (Ajzen, 1991) and TAM, and indicate that behavioural intention and perceived usefulness have positive direct effects on academic achievement. Similar results were also documented by Yahia Shams Eldin et al., (2025) who established that e-learning systems engagement among students is an important predictor of problem-solving and comprehension skills. This was also noted by Yusuf et al., (2025) who found that the greater the acceptance, the greater the use of digital learning tools translated to realised

performance. The partial mediation of technological acceptance between the AIEP use and SLO was confirmed by the Sobel test (Sobel statistic = 8.567, $p < 0.05$). This is according to the opposition found by Wahid and Awad (2025) and Saad et al., (2025) who indicated that the impact of technology adoption on learning is mainly achieved through the acceptance and engagement of students. Albeit, as opposed to full mediation reported in other instances in higher education, the partial mediation in this research demonstrates that the AIEP have a somewhat smaller impact on learning outcomes, though it remains dual with respect to direct platform functionality and mediated engagement influence. The direct impact of AI platforms on learning results ($\beta = 0.847, p = 0.05; \beta = 0.768$) supports the idea that the access to AI tools per se has a beneficial impact on the student performance. This agrees with the works of Qadeer et al., (2025) and Nagi (2024) who have shown that AI-facilitated adaptive systems are associated with better understanding and memory. The beta observed is a bit smaller than the mediated one which explains that technology, unless engaged and accepted, is not that effective. This observation goes hand in hand with Qadeer et al., (2025) and Awad et al., (2024) who underscored that perception and behavioural intention reinforce the impact of technology on outcomes. The correlation test showed that interactivity is the most influential factor on TA ($r = 0.893$) and SLO ($r = 0.867$) and then usability and adaptive functionality.

This supports earlier studies (Alghizzawi et al., 2025; Aldabousi et al., 2025) on the importance of user-friendly features that are engaging as the focus of digital learning. Personalization and feedback, on the other hand, although important were less correlated, which means that the effectiveness of the features can be context-dependent. This somewhat differs with Alfiras et al., (2021), who emphasised on personalization as the most dominant feature. The difference can be explained by the age of students, their previous experience with AI tools, and the school infrastructure, which highlights the need to address the contextual factors in the effectiveness of EdTech. All the findings are in favour of comprehensive use of TAM, TPB, and DOI theories. The characteristics of AI platform (DOI) also affect the perceptions of usefulness and ease of use (TAM) that in turn affect behavioural intention and acceptance (TPB) and eventually, learning outcomes are influenced. These results partially mediate technological acceptance, which supports the assertions of theory on how intention and acceptance are central to learning mediated by technology (Almeer et al., 2024; Aldabousi, 2024). In general, the findings of the study, in many ways, align with the previous research, which shows that educational technology, acceptance, and outcomes are positively correlated (Awad et al., 2025; Aldraiweesh and Alturki, 2025). The observed partial mediation is congruent with Nagi (2024) and Al-Sherman and Aldabousi (2024) but differs with the literature that finds full mediation in higher education settings, which is contextually varying when applied in K-12 schools. The fact that interactivity prevails over personalization is partly the opposite of Altemey et al., (2023), which implies that the elements of student engagement can be considered more significant than adaptive personalization with younger students. The findings also expand on the literature by highlighting the role of device access, digital literacy, and socioeconomic factors in determining the usefulness of AI tools, with the research being conducted in Karachi, private schools, which is the least examined.

Theoretical Contributions

The research has a number of considerable contributions to the theoretical literature on educational TA and SLO. First, it offers empirical evidence to the integration of the TAM, TPB and DOI frameworks to the K-12 education in Pakistan. The study explains how TA would lead to academic performance by illustrating that TA is a mediator of the impact of AIEP, which can be applied in higher education; thus, the study expand the previous research (Nazil, 2025; Obeidat et al., 2024). Second, the paper shows the different effects of AIEP characteristics, especially the interactivity, usability, and adaptive functionality on the acceptance and performance. It gives a more detailed theoretical insight into what aspects of AIEP generate engagement and result, which is relevant to the body of literature about EdTech design and learning analytics (Nagi & Mohammed Ali, 2020). Third, the study resolves a significant contextual gap through its study of a population, the private schools in Karachi, Pakistan, that has not been adequately covered in the previous research. The research contributes to the cross-cultural applicability of TAM, TPB, and DOI by showing that platform use relates to socioeconomic factors, device access, and digital literacy under contingent effects of contextual factors on the recognition of TA theories.

Practical Implications

The results provide practical information to educational establishments, policy-makers, and developers of EdTech. To begin with, the high persuasiveness of TA highlights the importance of schools in promoting the involvement and positive attitude towards AI tools in students by utilizing orientation courses, facilitated utilization and supportive digital environments. Second, the presence of interactivity, usability, and adaptive functionality as strategic dimensions can imply that developers need to emphasize interactive content, user-friendly interfaces, and adaptive learning paths to increase the educational impact to their fullest extent. Engaging and intuitive tools more adopted and lead to observable learning outcomes. Third, the study highlights the role of fair access to AIEP with disparities in device access and digital literacy having the power to mediate learning. These insights can be used by the policy makers and the private schools to focus on resource, training and infrastructure development so that the benefits of technology are made available to all students.

Limitations and Future Research Directions

Although the research is informative, it has a number of limitations. To begin with, the study is cross-sectional, thus limiting causality. It is possible that future research take the longitudinal or experimental design to study the change in the AIEP usage and acceptance with time and the resulting effect of the AIEP usage and acceptance on learning outcomes more rigorously. Second, the research only concentrates on Karachi based private schools, which cannot be generalized to other areas, government schools, or other systems of education. The given study should be repeated to different settings in future studies exploring the impact of the socioeconomic, cultural and institutional differences on the technology adoption and learning outcomes. Third, although five major dimensions of AIEP were measured, the study fails to reflect all the possible variables of affecting student engagement, including peer influence, teacher competence, or parental support. Incorporation of more variables could also be a part of future research to define a more comprehensive framework of the adoption of AIEP. Lastly, the research is based on self-reported learning outcome and acceptance measures, which may be prejudiced. Use of objective performance measurements, use logs or teacher-assessments in future study would bolster validity and reliability of the results.

6. Conclusion

This paper has explored the association between AIEP and TA and SLO in Karachi based private schools with TA as a mediator. The results have strong evidence that AIEP significantly improve SLO directly and indirectly by use of TA. The partial mediation effect indicates that student involvement and acceptance of AIEP are very important processes by which technology enhances student academic achievement. The findings show that the most influential features of AI platforms are interactivity, usability, and adaptive functionality, which are a strong motivating factor in TA and subsequently, learning outcomes. Although the values of personalization and feedback can also play their role, their effects are relatively moderate, which shows that the development of interactive and accessible AI tools in K-12 students is critical. The research establishes that TA is an important mediator, which enhances the learning outcomes of AI platforms. Besides this, the research expands the current theoretical models such as TAM, TPB, and DOI by bringing them together in the K-12 environment of Karachi, which proves that the digital learning platforms have the potential to positively impact student performance in developing country environments, through TA theories. The results also highlight the need to put into focus the contextual factors, including school infrastructure, digital literacy, and socioeconomic status, which could mediate on the efficacy of AIEP interventions. Altogether, the study can be regarded as adding to a better comprehension of how the AIEP influences the process of learning, since both the design of technology and the willingness of the students play a crucial role before yielding significant academic results. The research addresses a significant gap in the literature since it targets K-12 private schools in Pakistan that serve as a basis to subsequent research and policy programs that could be used to promote technology-enhanced learning in comparable settings.

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 human participants or the collection of sensitive personal data. The research is based on bibliometric methods, utilising secondary data exclusively from the Scopus database. 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

Dr Rizwan Ahmed¹: Conceptualization, Data curation, Formal analysis, Writing – original draft

Data availability

The data generated and analyzed during the current study are not publicly available due to confidentiality agreements with participants and institutional restrictions. However, the dataset supporting the findings of this study is securely stored by the authors and can be made available from the corresponding author upon reasonable request.

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