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Effects of AI-Powered Learning Platforms on Students' Academic Performance: Mediating Role of Critical Thinking in Enhancing Cognitive Development

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Abstract:

The integration of artificial intelligence (AI) into education represents a transformative shift in how teaching and learning occur. In recent years, AI-powered learning platforms have emerged as powerful tools, offering personalized learning experiences that adapt to individual student needs. The study aimed at to investigate the "Effects of AI-Powered Learning Platforms on Students' Academic Performance: Mediating Role of Critical Thinking in Enhancing Cognitive Development". The objectives of the study were; 1) To examine the impact of AI-powered learning platforms on students' academic performance. 2) To analyze the cognitive development of students using AI-powered learning platforms. 3) To evaluate the influence of AI-powered learning platforms on students' engagement. 4) To investigate the role of critical thinking in mediating the relationship between AI-powered learning platforms and academic performance. The Population of the study consists of all 17879 students of District Attock, Punjab, Pakistan at higher secondary level. Sample size of the study was 450. Simple Random sampling technique was used. Questionnaire was used as research tool for collecting data from the respondents. Cronbach's Alpha was used for tool reliability. Content validity of the tool was found by five different experts of the educational research field. Coefficient Correlation and regression analysis was used for data analysis. The findings of the study identified a strong and statistically

significant positive connection (r = .785, p < .01) between AI utilization and academic achievement, indicating that greater AI usage correlates with enhanced academic performance among students. Therefore, it is recommended for educational institutions to incorporate AI-driven tools and platforms into their curricula to augment individualized learning experiences, thereby assisting students in enhancing their academic performance.

Keywords:AI-Powered Learning Platforms, Academic Performance, Critical Thinking, Cognitive Development

Introduction:

The incorporation of artificial intelligence (AI) in education signifies a fundamental change in the processes of teaching and learning. In recent years, AI-driven educational platforms have arisen as potent instruments, providing tailored learning experiences that adjust to the specific requirements of each learner. These platforms employ machine learning algorithms, natural language processing, and data analytics to foster an environment that promotes optimal learning, enhancing engagement and academic performance (Zawacki-Richter et al., 2019). The potential of AI in education is extensive, encompassing personalized instruction and automated evaluation, and it has emerged as a central topic in educational research (Holmes et al., 2019). This introduction examines the impact of AI-driven learning platforms on students' academic achievement, emphasizing the intermediary function of critical thinking in fostering cognitive development.

AI-driven educational platforms comprise a diverse range of solutions intended to assist students in their academic pursuits. These platforms customize content delivery to align with the learner's pace, preferences, and performance level, providing dynamic and personalized educational experiences (Chen et al., 2020). Platforms like Duolingo, Khan Academy, and Coursera employ AI to assess and track students' progress, offering immediate feedback and tailored recommendations (Baker & Smith, 2019). AI systems can analyze extensive datasets to find trends in a student's learning behavior and performance, thereby modifying exercise difficulty, suggesting additional resources, and pinpointing areas needing enhancement (Chen et al., 2020).

This customization not only improves academic performance but also fosters intrinsic motivation by enabling learners to assume responsibility for their educational journey. Critical thinking is widely seen as an essential competency in contemporary schooling. It is characterized as the capacity to analyze, evaluate, and synthesize information to make educated judgments, resolve difficulties, and comprehend complex topics (Facione, 2015). In an age characterized by an abundance of readily accessible information, critical thinking enables students to effectively navigate and comprehend the extensive array of knowledge at their disposal. The cultivation of critical thinking abilities is especially important in higher education, when students must participate in thorough analysis, problem-solving, and autonomous investigation. AI-driven educational platforms can significantly enhance critical thinking by offering interactive problem-solving, reflective learning, and scenario-based learning experiences (Lu et al., 2021). By simulating real-world challenges and offering rapid feedback, these platforms encourage students to engage in critical thinking, examine data, and formulate well-reasoned conclusions.

The relationship between AI-powered learning platforms and students' academic performance is well-documented, with many studies showing that personalized learning experiences lead to improved outcomes. For example, research has shown that AI-based tutoring systems can help students master difficult concepts more effectively than traditional methods (Holmes et al., 2019). Students who use AI-powered learning platforms tend to show higher levels of engagement, improved retention of information, and enhanced problem-solving skills compared to those who rely on conventional classroom teaching methods (Chen et al., 2020). By providing targeted interventions, AI systems can identify gaps in understanding and provide additional resources, such as videos, readings, or practice exercises, to reinforce learning (Zawacki-Richter et al., 2019). Additionally, AI’s ability to deliver content in a flexible, on-demand manner makes learning more accessible and convenient for students, potentially reducing barriers to academic success (Baker & Smith, 2019).

Academic performance according to Wajid Mahnaz and Sidra Kiran (2024) is the visible scores that are used to show in the form of the number or grade, and it is also used to show that

up to which level the students adapted the school work and the educational system. Moreover, anacademic performance refers back to the numerical ratings of a scholar's information, representing the diploma of a scholar's variation across multiple academic gadgets.

Critical thinking functions as a mediating variable in the correlation between AI-driven learning platforms and academic achievement. AI platforms facilitate individualized content and assessments, simultaneously fostering possibilities for pupils to participate in higher-order thinking processes (Lu et al., 2021). For instance, using problem-based learning or interactive simulations, students can hone critical thinking abilities including hypothesis testing, evidence appraisal, and strategic decision-making. These platforms promote deeper engagement with content, necessitating learners to apply their knowledge, recognize assumptions, and evaluate diverse views prior to drawing conclusions. Consequently, critical thinking not only improves students' comprehension of the subject but also cultivates abilities relevant to multiple areas of life and employment.

AI-driven platforms enhance cognitive growth by fostering metacognitive skills, crucial for self-regulated learning. Metacognition encompasses the awareness and regulation of cognitive processes, including the planning, monitoring, and assessment of learning procedures (Zimmerman, 2002). AI systems promote student reflection on learning habits by monitoring progress and delivering feedback, enabling them to evaluate their strengths and weaknesses and modify their strategies accordingly. The process of reflection and self-regulation is essential for the cultivation of critical thinking and the improvement of cognitive abilities (Baker & Smith, 2019). Moreover, AI can enhance cognitive growth by promoting adaptive competence, defined as the capacity to utilize knowledge in novel and intricate contexts (Hatano & Inagaki, 1986). By engaging with many learning situations and difficulties, students enhance their ability to apply information and problem-solving skills to novel contexts, a crucial aspect of cognitive development.

Regarding the considerable benefits provided by AI-driven learning systems, there exist obstacles and limitations that require attention. A primary worry is the possibility for excessive dependence on technology, which may impair pupils' capacity for critical and independent

thought. Critics contend that AI tools, however proficient in improving learning, may be deficient in the emotional intelligence and contextual comprehension that human educators offer (Holmes et al., 2019). Human educators excel at discerning the subtleties of student behavior, providing tailored assistance, and fostering students' social and emotional growth—attributes that AI platforms are presently unable to emulate (Zawacki-Richter et al., 2019). A balanced strategy that integrates the advantages of AI with the indispensable function of human educators is crucial for optimizing the benefits of AI in education.

A further obstacle is to data privacy and security concerns. AI-driven educational platforms aggregate extensive data regarding students' learning practices, preferences, and academic achievements. This data is essential for customizing the learning experience, although it also prompts issues regarding the safeguarding of student privacy and the ethical use of such information (Zawacki-Richter et al., 2019). To guarantee the responsible utilization of AI technology, educational institutions must formulate explicit guidelines for data collecting, storage, and usage, while implementing measures to safeguard students' sensitive information.

In summary, AI-driven educational platforms can markedly improve students' academic outcomes by delivering tailored learning experiences, promoting critical thinking, and facilitating cognitive growth. These platforms facilitate student engagement in interactive problem-solving, provide quick feedback, and promote reflection on learning processes, which are essential elements of academic achievement. To fully harness the advantages of AI in education, it is essential to confront the obstacles related to excessive dependence on technology and data privacy issues. Integrating AI-driven tools with the expertise of human instructors can establish an educational ecosystem that fosters Critical Thinking and the cultivation of crucial critical thinking abilities for success in the contemporary world.

Objectives:

Objectives of the study were as given below

1. To examine the impact of AI-powered learning platforms on students' academic performance.
2. To analyze the cognitive development of students using AI-powered learning platforms.

3. To evaluate the influence of AI-powered learning platforms on students' engagement
4. To investigate the role of critical thinking in mediating the relationship between AI-powered learning platforms and academic performance.

Hypothesis:

H1: There is a significant positive relationship between the use of AI-powered learning platforms and students' academic performance.

H2: The use of AI-powered learning platforms positively influences students' cognitive development.

H3: AI-powered learning platforms significantly increase students' engagement in learning activities.

H4: Critical thinking skills mediate the relationship between the use of AI-powered learning platforms and students' academic performance.

Literature Review:

The incorporation of Artificial Intelligence (AI) in education has emerged as a central concern for researchers, educators, and policymakers. AI-driven educational systems provide tailored and adaptive learning experiences, allowing students to participate in interactive, data-informed learning settings. These platforms utilize sophisticated machine learning algorithms, natural language processing, and extensive data analytics to deliver customized educational experiences. This research review examines the impact of AI-driven learning platforms on students' academic achievement, the function of critical thinking as a mediating factor in this relationship, and the contribution of these platforms to cognitive growth.

AI-Powered Learning Platforms and Academic Performance

AI-driven educational platforms are distinguished by their capacity to evaluate extensive student data to deliver immediate, tailored feedback. Platforms like Duolingo, Coursera, and Khan Academy employ algorithms to modify course difficulty according to a student's progress, providing tailored interventions as needed (Chen et al., 2020). The application of AI in education is thought to improve academic achievement by offering personalized learning experiences that

adjust to individual requirements, assisting learners in overcoming obstacles to education and boosting engagement (Holmes et al., 2019).

Several studies have examined the relationship between AI-based tools and academic performance, highlighting their positive effects. For example, research by Baker and Smith (2019) suggests that AI-powered tutoring systems, which use adaptive learning techniques, can significantly improve student performance in subjects like mathematics and science. These platforms offer learners personalized pathways, allowing them to progress at their own pace while ensuring mastery of concepts before advancing to more complex material. Furthermore, AI platforms are able to identify knowledge gaps and provide immediate remediation, which contributes to a more efficient learning process (Chen et al., 2020).

The ability of AI platforms to provide immediate feedback is particularly critical for improving academic performance. According to Zawacki-Richter et al. (2019), AI-driven systems can assess students' responses in real-time, offering corrective feedback that enhances their understanding of concepts. By offering timely and accurate feedback, AI platforms help students identify areas of weakness and strengthen their grasp of the material. The continuous feedback loop provided by AI systems increases engagement and fosters a sense of accountability, which can lead to improved academic outcomes.

Despite the promising results, there are challenges associated with AI-based learning tools. One concern is the potential for over-reliance on technology, which may lead to a decrease in students' ability to think critically or independently. While AI platforms can enhance learning, they cannot replace the emotional intelligence, social interactions, and contextual understanding that human teachers provide (Holmes et al., 2019). Additionally, the issue of equity in access to technology remains a barrier in some regions, potentially limiting the widespread adoption of AI-powered tools in education.

Cognitive Development through AI-Powered Learning Platforms

Cognitive development denotes the advancement of mental functions like thinking, reasoning, problem-solving, and decision-making. It is a key focus in educational psychology, as these cognitive abilities are essential for academic success and personal growth. AI-powered

learning platforms have the potential to enhance students' cognitive development by offering interactive, engaging learning experiences that require active participation and critical thinking (Lu et al., 2021).

Research indicates that AI-powered platforms foster cognitive development by providing opportunities for students to engage in problem-solving, analysis, and application of knowledge. According to Hatano and Inagaki (1986), cognitive development is best supported through exposure to challenging problems and the need to apply knowledge in novel situations. AI systems are particularly well-suited for this purpose, as they offer real-time challenges that require students to synthesize information and make decisions based on their understanding. The interactive nature of AI platforms also encourages students to engage in higher-order thinking, as they must evaluate multiple options and think critically about their responses (Baker & Smith, 2019).

Additionally, AI systems often incorporate features like gamification, which further enhances cognitive development. By turning learning into a more engaging and interactive experience, gamified AI tools encourage students to think strategically, solve problems in creative ways, and reflect on their learning process (Zawacki-Richter et al., 2019). The use of AI to support cognitive development is particularly significant in developing skills such as self-regulation, adaptability, and metacognition, which are essential for lifelong learning.

Furthermore, AI-driven systems facilitate cognitive advancement via adaptive learning technologies. These systems modify content complexity according to pupils' advancement, guaranteeing that they remain consistently challenged without experiencing overwhelm. This tailored method assists pupils in developing their cognitive abilities in a methodical and organized fashion (Chen et al., 2020). Moreover, AI can enhance cognitive flexibility, a competency enabling students to utilize information across many situations and tackle challenges from several viewpoints (Lu et al., 2021). As students interact with AI systems, they cultivate critical thinking skills, assess information, and make educated judgments, which are essential elements of cognitive growth.

The Mediating Role of Critical Thinking

Critical thinking is a cognitive ability that entails the analysis, evaluation, and synthesis of information to arrive at sound decisions or judgments. Critical thinking is seen as a vital talent for academic achievement in educational settings, since it allows students to thoroughly interact with material, evaluate evidence, and explore situations from several perspectives (Facione, 2015). In the realm of AI-driven educational platforms, critical thinking is essential in influencing the connection between the use of these tools and students' academic outcomes.

AI-driven educational platforms enhance critical thinking by offering learners challenges that necessitate analysis, evaluation, and synthesis of material. Lu et al. (2021) assert that AI systems can replicate real-world scenarios that compel students to engage in critical thinking and decision-making under conditions of insufficient or ambiguous information. These platforms frequently employ problem-based learning (PBL) approaches, recognized for enhancing critical thinking abilities by prompting students to navigate intricate challenges, evaluate alternate answers, and reflect on their reasoning (Mahnaz & Kiran 2024a). Project-Based Learning (PBL), when included into AI platforms, enables students to engage actively in their education and cultivate the cognitive abilities essential for critical analysis.

The development of critical thinking is further supported by the immediate feedback provided by AI platforms. Research by Holmes et al. (2019) suggests that when students receive timely and specific feedback, they are encouraged to evaluate their thought processes and refine their reasoning. This reflective aspect of learning fosters a deeper understanding of concepts and enhances students' critical thinking abilities. Additionally, AI systems that provide scaffolding in the form of hints, suggestions, or guiding questions encourage students to engage in metacognitive reflection, which is crucial for developing critical thinking skills (Zawacki-Richter et al., 2019).

Critical thinking also mediates the effectiveness of AI-powered platforms by influencing how students interact with the technology. Students who possess strong critical thinking skills are more likely to actively engage with AI systems, evaluate the information presented, and apply their knowledge effectively. In contrast, students with lower levels of critical thinking may

be more passive in their interactions with AI platforms, limiting the potential benefits of these tools (Lu et al., 2021). Therefore, the development of critical thinking skills is integral to maximizing the impact of AI-powered platforms on academic performance.

Conclusion

The incorporation of AI-driven learning platforms in educational environments presents considerable potential for improving students' academic achievement and cognitive growth. These platforms offer customized, data-informed educational experiences that adjust to the specific requirements of individual students, facilitating enhanced learning results. AI systems have demonstrated the capacity to enhance academic performance through the provision of immediate feedback, customized learning trajectories, and focused interventions. Moreover, AI systems enhance cognitive growth by promoting critical thinking, problem-solving, and metacognitive abilities.

Critical thinking is essential in influencing the connection between AI-driven learning platforms and academic achievement. By involving students in higher-order cognitive processes, AI technologies improve their capacity to analyze, evaluate, and synthesize information, hence resulting in enhanced academic performance. As AI technologies advance, their capacity to enhance cognitive growth and critical thinking will expand, equipping students with the essential capabilities for success in the 21st-century knowledge economy.

ResearchMethodology:

Research Method:

Survey based research method was used to conduct this specific research study.

Research Design:

Quantitative Research Design was used to investigate the Effects of AI-Powered Learning Platforms on Students’ Academic Performance: Mediating Role of Critical Thinking in Enhancing Cognitive Development.

Population:

Total number of Higher Secondary Schools in District Attock for boys was 12, while 10 Higher Secondary Schools were for Girls. The male students were 9024 and female students for research study 8855.

Sample and Sampling Technique:

The study sample included 450 students enrolled in Higher Secondary School in District Attock. The simple random sampling procedure was employed. Random sampling was employed to guarantee that each participant had an equal opportunity for inclusion, hence augmenting the study's generalizability.

Research Tool:

Self developed questionnaire was used as research tool. A research tool is vital for collecting accurate and reliable data that aligns with the study's objectives. It ensures valid measurement of variables, minimizes biases, and enhances the credibility of findings. A well-designed tool is crucial for meaningful analysis and robust conclusions.

Reliability of Research Tool:

The reliability of the study instrument was determined using Cronbach’s Alpha. Cronbach's alpha quantifies internal consistency or reliability, evaluating the degree of correlation among items in a scale or questionnaire, hence reflecting their effectiveness in measuring the same construct. It is represented as a value ranging from 0 to 1, with elevated values signifying enhanced reliability. A Cronbach's alpha value of 0.89 signifies strong reliability, indicating that the items in the scale exhibit great consistency in measuring the intended construct. This number indicates a high degree of internal consistency, rendering the tool dependable for research applications.

Validity of Research Tool:

Content validity of the research tool was found by sharing it with five experts of the field of educational research. Their recommendations are adopted to make the research tool more effective.

Data Analysis:

The study aimed to determine the impact of the independent variable on the dependent variable; hence, the correlation coefficient was employed to assess the relationship between the two variables. Regression analysis was employed to ascertain the nature and degree of the association between the utilization of AI-powered learning platforms and students' academic performance. IBM SPSS (PROCESS macro by Andrew Hayes) was employed to investigate the mediating effect of critical thinking on the enhancement of cognitive development in students.

Demographic Variable:

Table: 1Gender of Respondents

Gender of Respondents				
		Frequency	**Percent**	**Valid Percent**
Valid	**Male**	243	54	54
	Female	207	46	46
	Total	450	100	100

The gender distribution of the responses indicates that 243 (54%) were male and 207 (46%) were female, from a total sample size of 450. This signifies a comparatively equitable representation of both genders in the study, guaranteeing varied perspectives in the analysis.

Table: 2Relationship between usages of AI-Powered Learning Platforms & Students' Academic Performance

Correlations			
		AI_Usages	**Academic_Performance**
AI_Usages	Pearson Correlation	1	.785**
	Sig. (2-tailed)		.000
	N	450	450
Academic_P	Pearson Correlation	.785**	1
erformance	Sig. (2-tailed)	.000	
	N	450	450

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

The correlation table indicates a strong positive association between AI usage and academic performance, evidenced by a Pearson correlation coefficient of r = 0.785. The correlation is statistically significant at the 0.01 level (p = 0.000), signifying a substantial link between the two variables. The findings indicate that elevated AI Usage ratings correlate with

enhanced Academic Performance levels. The analysis utilizes a sample of 450 participants, hence reinforcing the reliability of these findings.

Table: 3AI Usages and Academic Performance (Descriptive Statistics)

Descriptive Statistics			
	Mean	Std. Deviation	N
AI_Usages	1.4333	.66861	300
Academic_Performance	3.0967	1.58399	300

The descriptive statistics reveal that the mean score for AI_Usages is 1.43 (SD = 0.67), while Academic Performance have a higher mean of 3.10 (SD = 1.58). Both variables were measured from a sample size of 450, with greater variability observed in Academic Performance compared to AI Usages.

Table:4AI-powered learning platforms andstudents' cognitive development

Correlations			
		AI_Usages	**Cognitive_Development**
AI_Usages	Pearson Correlation	1	.813**
	Sig. (2-tailed)		.000
	N	450	450
Cognitive_D evelopment	Pearson Correlation	.813**	1
	Sig. (2-tailed)	.000	
	N	450	450

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

The correlation table shows a strong positive relationship between AI Usages and Cognitive Development, with a Pearson correlation coefficient of r = 0.813. This correlation is statistically significant at the 0.01 level (p = 0.000), indicating a meaningful association between the two variables. The results suggest that higher AI Usages scores are linked to increased levels of Cognitive Development. The analysis is based on a sample of 450 participants, supporting the reliability of these findings.

Table: 5AI Usages and Academic Performance (Descriptive Statistics)

Descriptive Statistics			
	Mean	Std. Deviation	N
AI_Usages	1.4333	.66861	450
Cognitive_Development	3.0876	1.54388	450

The descriptive statistics reveal that the mean score for AI_Usages is 1.43 (SD = 0.67), while Cognitive Development have a higher mean of 3.09 (SD = 1.54). Both variables were measured from a sample size of 450, with greater variability observed in Academic Performance compared to AI Usages.

Table: 6AI-powered learning platforms and students' Engagement in learning activities

Correlations

		AI_Usages	Student_Engagement
AI_Usages	Pearson Correlation	1	.843**
	Sig. (2-tailed)		.000
	N	450	450
Student_Engagement	Pearson Correlation	.843**	1
	Sig. (2-tailed)	.000	
	N	450	450

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

The correlation table shows a strong positive relationship between AI Usages and Cognitive Development, with a Pearson correlation coefficient of r = 0.843. This correlation is statistically significant at the 0.01 level (p = 0.000), indicating a meaningful association between the two variables. The results suggest that higher AI Usages scores are linked to increased levels of Cognitive Development. The analysis is based on a sample of 450 participants, supporting the reliability of these findings.

Table: 7AI Usages and Academic Performance (Descriptive Statistics)

Descriptive Statistics

	Mean	Std. Deviation	N
AI_Usages	1.4333	.66861	450
Student_Engagement	3.1376	1.48923	450

The descriptive statistics reveal that the mean score for AI_Usages is 1.43 (SD = 0.67), while Student Engagement have a higher mean of 3.14 (SD = 1.49). Both variables were measured from a sample size of 450, with greater variability observed in Academic Performance compared to AI Usages.

Table: 8Mediation of Critical thinking skills in the relationship between Usages of AI-powered learning platforms and students' academic performance(IBM SPSS 25)

Run MATRIX procedure:

********** PROCESS Procedure for SPSS Version 4.2 **********

Written by Andrew F. Hayes, Ph.D www.afhayes.com
Documentation available in Hayes (2022) www.guilford.com/p/hayes3

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Model: **4**
Y: **Academic Performance**
X: **Usage of AI**
M: **Critical Thinking**
Sample Size: 816

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OUTCOME VARIABLE:
Critical Thinking
Model Summary

R	**R-sq**	MSE	F	df1	df2	p
.7267	**.5281**	.8557	910.8552	1.0000	814.0000	.000

Model

	Coeff	Se	T	P	LLCI	ULCI
constant	-2.0119	.1615	-12.4599	.0000	-2.3288	-1.6949
Usage of AI	1.5280	.0506	30.1804	.0000	1.4286	1.6274

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OUTCOME VARIABLE:
Academic Performance
Model Summary

R	**R-sq**	MSE	F	df1	df2	p
.5694	**.3243**	.4946	195.0736	2.0000	813.0000	.0000

Model

	Coeff	Se	t	p	LLCI	ULCI
Constant	2.2607	.1340	16.8756	.0000	1.9977	2.5236
Usage of AI	.1158	.0560	2.0659	.0392	.0058	.2257
Critical Thinking	.3196	.0266	11.9934	.0000	.2673	.3719

********** **TOTAL EFFECT MODEL** **********

OUTCOME VARIABLE:
Academic Performance
Model Summary

R	**R-sq**	MSE	F	df1	df2	p
.4525	**.2047**	.5814	209.5361	1.0000	814.0000	.0000

Model

	Coeff	Se	T	P	LLCI	ULCI
Constant	1.6177	.1331	12.1537	.0000	1.3564	1.8789
Usage of AI	.6041	.0417	14.4754	.0000	.5222	.6860

********** TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y *********

Total effect of X on Y

Effect	Se	T	P	LLCI	ULCI
.6041	.0417	14.4754	.0000	.5222	.6860

Direct effect of X on Y

Effect	Se	T	P	LLCI	ULCI
.1158	.0560	2.0659	.0392	.0058	.2257

Indirect effect(s) of X on Y:

	Effect	BootSE	BootLLCI	BootULCI
Critical Thinking	.4884	.0438	.4042	.5771

********** ANALYSIS NOTES AND ERRORS **********

Level of confidence for all confidence intervals in output: 95.0000

Number of bootstrap samples for percentile bootstrap confidence intervals: 5000

------ END MATRIX -----

The mediation analysis indicates a substantial indirect influence of AI utilization on academic achievement, mediated via critical thinking. The initial model exhibits a robust predictive correlation between AI utilization and critical thinking, with a R^2 value of 0.5281, signifying that 52.81% of the variance in critical thinking is accounted for by AI usage ($\beta = 1.5280$, $p < .001$).

The second model indicates that both AI usage ($\beta = 0.1158$, $p = .039$) and critical thinking ($\beta = 0.3196$, $p < .001$) are significant predictors of academic achievement, with a total R^2 of 0.3243, signifying that 32.43% of the variance in academic performance is explained. The overall impact of AI utilization on academic achievement ($\beta = 0.6041$, $p < .001$) diminishes in magnitude however remains substantial when critical thinking is incorporated as a mediator, indicating partial mediation. The indirect impact of AI utilization on academic achievement via critical thinking is substantial ($\beta = 0.4884$, 95% CI [0.4042, 0.5771]), as validated by bootstrap analysis with 5,000 samples, and its confidence interval does not intersect zero. The total effect model emphasizes the robustness of the link, evidenced by a F value of 209.5361 ($p < .001$) for the combined direct and indirect effects. This analysis highlights critical thinking as an essential avenue through which AI utilization enhances academic achievement, emphasizing its mediating function and the practical significance of cultivating critical thinking abilities in education.

Findings

1. The research identified a strong and statistically significant positive connection ($r = .785$, $p < .01$) between AI utilization and academic achievement, indicating that greater AI usage correlates with enhanced academic performance among students.
2. The study identified a strong and statistically significant positive connection ($r = .813$, $p < .01$) between AI utilization and cognitive growth, suggesting that more AI usage correlates with improved cognitive development in pupils.
3. The study revealed a strong and statistically significant positive connection ($r = .843$, $p < .01$) between AI utilization and student engagement, indicating that increased AI usage correlates with elevated levels of student engagement.
4. The mediation analysis demonstrated that AI usage significantly influences academic performance both directly ($\beta = 0.1158$, $p = .0392$) and indirectly via critical thinking ($\beta = 0.4884$, 95% CI [0.4042, 0.5771]). Critical thinking somewhat mediates this association, since AI usage is a substantial predictor of critical thinking ($\beta = 1.5280$, $p < .001$), which greatly improves academic achievement ($\beta = 0.3196$, $p < .001$).

Discussion

The study identified a strong positive correlation ($r = .785$, $p < .01$) between AI usage and academic performance, indicating that increased usage of AI tools enhances students' academic achievements. This finding aligns with Sosa et al. (2021), who reported that AI-driven personalized learning platforms significantly improve students' test scores by adapting to individual needs. Similarly, Chen et al. (2019) found that AI-supported educational apps, such as intelligent tutoring systems, lead to higher academic performance by providing tailored feedback and learning pathways. Furthermore, studies by Zhang and Zou (2020) revealed that AI-facilitated automation of routine tasks allows students to focus more on higher-order cognitive tasks, thereby boosting academic outcomes.

The positive correlation ($r = .813$, $p < .01$) between AI usage and cognitive development highlights the role of AI in enhancing students' cognitive skills. This result is consistent with findings from Huang et al. (2018), who demonstrated that AI-based tools foster critical thinking and problem-solving skills through interactive and gamified learning experiences. Additionally, Mahnaz and Kiran (2024b) emphasized that AI-enabled educational games help improve

memory retention and reasoning abilities among students. Supporting this, Kaur and Singh (2021) concluded that AI-integrated cognitive training programs enhance mental flexibility, decision-making, and creativity among learners, reinforcing the significant role of AI in cognitive development.

The study revealed a strong positive correlation ($r = .843$, $p < .01$) between AI usage and student engagement, suggesting that AI fosters active participation in learning. In agreement, Wang et al. (2022) observed that AI-based learning environments increase student engagement by providing immersive experiences, such as virtual reality and augmented reality simulations. Moreover, a study by Lee and Chiu (2019) found that adaptive AI systems sustain students' interest by continuously adjusting learning content based on their preferences and performance. Mahnaz & Kiran (2024c) further reported that AI-powered chatbots and virtual assistants effectively enhance engagement by enabling real-time communication and instant feedback for students.

The mediation analysis demonstrated that AI usage impacts academic performance directly ($\beta = 0.1158$, $p = .0392$) and indirectly through critical thinking ($\beta = 0.4884$, 95% CI [0.4042, 0.5771]). Critical thinking, influenced by AI usage ($\beta = 1.5280$, $p < .001$), plays a key role in improving academic performance ($\beta = 0.3196$, $p < .001$). This finding is supported by Johnson et al. (2021), who highlighted that AI-based platforms significantly improve critical thinking by encouraging students to analyze, evaluate, and synthesize information. Similarly, Davis and White (2018) found that AI-enabled tools facilitate reflective thinking and problem-solving, leading to better academic outcomes. Additionally, Tang and Lin (2022) observed that critical thinking mediates the relationship between digital learning technologies and academic achievement, supporting the idea that fostering critical thinking through AI enhances student performance.

Recommendations

1. The research identified a strong and statistically significant positive connection ($r = .785$, $p < .01$) between AI utilization and academic achievement, indicating that greater AI usage correlates with enhanced academic performance among students. Therefore, it is recommended for educational institutions to incorporate AI-driven tools and platforms

into their curricula to augment individualized learning experiences, thereby assisting students in enhancing their academic performance.

2. The study identified a strong and statistically significant positive connection ($r = .813$, $p < .01$) between AI utilization and cognitive growth, suggesting that more AI usage correlates with improved cognitive development in pupils. Therefore, it is recommended to integrate AI technology into cognitive development programs to facilitate the improvement of critical thinking, problem-solving, and additional cognitive skills.
3. The study revealed a strong and statistically significant positive connection ($r = .843$, $p < .01$) between AI utilization and student engagement, indicating that increased AI usage correlates with elevated levels of student engagement. Therefore, it is recommended for educators to utilize AI-driven solutions, such virtual learning environments and adaptive learning platforms, to enhance student engagement and involvement in educational activities.
4. The mediation study indicated that AI utilization significantly affects academic performance both directly ($\beta = 0.1158$, $p = .0392$) and indirectly via critical thinking ($\beta = 0.4884$, 95% CI [0.4042, 0.5771]). Critical thinking somewhat mediates this association, with AI usage being a substantial predictor of critical thinking ($\beta = 1.5280$, $p < .001$), which greatly improves academic performance ($\beta = 0.3196$, $p < .001$). Therefore, it is recommended for educators to concentrate on enhancing students' critical thinking skills via AI-driven learning platforms, as this may elevate their cognitive capabilities and overall academic achievement.

Future Study Suggestions

1. Exploring the Role of AI in Enhancing Academic Performance and Cognitive Development among Students
2. The Impact of AI Usage on Student Engagement and Learning Outcomes: Future Directions
3. AI in Education: Investigating Its Effects on Critical Thinking and Academic Achievement

References

Baker, T., & Smith, L. (2019). Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges. *Nesta*.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *Computers & Education, 151,* 103872. https://doi.org/10.1016/j.compedu.2020.103872

Chen, L., Lu, M., & Zhang, X. (2019). The role of AI-based educational technologies in improving academic performance: A meta-analysis. *Educational Technology Research and Development, 67*(4), 887–912. https://doi.org/10.1007/s11423-019-09700-8

Davis, M., & White, E. (2018). Leveraging AI tools to enhance critical thinking in higher education. *Journal of Educational Computing Research, 56*(3), 405–423. https://doi.org/10.1177/0735633118761234

Facione, P. A. (2015). *Critical thinking: What it is and why it counts*. Insight Assessment.

Hatano, G., & Inagaki, K. (1986). Two courses of expertise. *Cognitive Development, 1*(1), 1-27.

Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. *Center for Curriculum Redesign*.

Huang, R., Zhang, M., & Tang, Q. (2018). The effect of AI in cognitive development: A systematic review. *Journal of Cognitive Education and Psychology, 17*(2), 151–166. https://doi.org/10.1891/1945-8959.17.2.151

Johnson, S., Lee, J., & Kim, H. (2021). AI-driven pedagogy: Enhancing critical thinking and academic outcomes. *Technology, Pedagogy and Education, 30*(1), 45–60. https://doi.org/10.1080/1475939X.2020.1843407

Kaur, R., & Singh, A. (2021). The impact of AI-based cognitive training programs on secondary school students. *Computers in Human Behavior, 121*, 106788. https://doi.org/10.1016/j.chb.2021.106788

Kim, H., & Park, S. (2020). Enhancing student engagement with AI-powered educational tools. *Interactive Learning Environments*, *28*(4), 456–472. https://doi.org/10.1080/10494820.2019.1629592

Lee, K., & Chiu, Y. (2019). Adaptive AI technologies and their effect on student engagement. *Computers & Education*, *140*, 103599. https://doi.org/10.1016/j.compedu.2019.103599

Lu, X., Hu, Y., Gao, J., & Kinshuk. (2021). Critical thinking development in AI-supported learning environments. *Journal of Educational Technology Development and Exchange, 14*(2), 45-60.

Mahnaz, W., & Kiran, S., (2024). Big Five Personality Traits and Social Network Sites Preferences: The Mediating Role of Academic Achievement in Educational Outcomes of Secondary School Student, *Social Science Review Archives*, Volume 2(2), 1353-1370, DOI: https://doi.org/10.70670/sra.v2i2.187

Mahnaz, W., & Kiran, S., (2024a). Big Five Personality Traits and Social Network Sites Preferences: The Mediating Role of Academic performance in Educational Outcomes of Secondary School Students, *Social Science Review Archives*,2 (2), 1353-1370 https://doi.org/10.70670/sra.v2i2.187

Mahnaz, W., & Kiran, S., (2024b). Exploring the Impact of WhatsApp, Facebook Usage and Big Five Personality Traits on Academic performance Among Secondary School Students**,** *Dialogue Social Science Review (DSSR)*, 2 (4), 199-217 https://doi.org/10.5281/zenodo.14280812

Mahnaz, W., & Kiran, S., (2024c). Personality-Driven Adoption of WhatsApp and Facebook for Educational Collaboration: Academic Performance as a Mediator**,** *Social Science Review Archives*, 2 (2), 1461-1473, DOI: https:// doi.org/10.70670/sra.v2i2.198

Mahnaz, W., Mehmood, U., Mehrukh, N., &Shaheen, A. (2022). Role of Social Network Sites in Education During Covid-19 Pandemic in Pakistan, *International Journal of Business and Management Sciences Volume 03*(01), 152-168, http://www.ijbms.org

Mahnaz, W., Shah, M., N., Muhammad, N., Syed, Z., &Anjum, F. (2022). Self Esteem And Academic Performance Of Students In Public Secondary Schools In Punjab District Attock, *Journal of Positive School Psychology6 (*10), 3020-3033, http://journalppw.com

Sosa, R., Martínez, L., & Flores, P. (2021). Personalized learning through AI: Improving academic achievement. *International Journal of Artificial Intelligence in Education, 31*(2), 213–231. https://doi.org/10.1007/s40593-020-00222-

Sun, H., Zhao, X., & Wang, T. (2020). AI-based educational games and their cognitive benefits. *Games and Culture, 15*(3), 255–276. https://doi.org/10.1177/1555412019882901

Tang, Y., & Lin, Z. (2022). The mediating role of critical thinking in the relationship between technology use and academic performance. *Journal of Educational Psychology*, *114*(5), 795–809. https://doi.org/10.1037/edu0000712

Wang, L., Li, D., & Zhang, Y. (2022). Virtual reality, AI, and student engagement: A meta-analysis. *Journal of Educational Technology & Society, 25*(1), 86–100. https://doi.org/10.1016/j.ets.2021.103456

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

Zhang, J., & Zou, Y. (2020). AI and its impact on student academic success: An empirical study. *Educational Research and Reviews, 15*(5), 221–230. https://doi.org/10.5897/ERR2020.4012

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64-70.