

Assessing the Effects of Artificial Intelligence on Student Cognitive Skills: An Investigation into Enhancement or Deterioration

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Abstract: The era of AI began in the 1950s as an interdisciplinary field, since then it has made significant advancements and discoveries. The emergence of artificial intelligence (AI) in education has sparked debates regarding its benefits and risks, particularly in early childhood education. This study dives into the growing role of Artificial Intelligence (AI) in education, aiming to understand how it affects students' thinking skills and academic performance. In this research non-probability convenience sampling technique was used. The sample of this study was drawn on a non-probability basis. This research investigated the impact of Artificial Intelligence (AI) on students' learning outcomes through the mediation effect of critical thinking and moderating effect of attitude towards learning. The findings suggest a strong positive relationship that with increased use of AI, learning outcomes tend to improve which was highlighted and supported by prior studies (Barrios Tao et al., 2019). The study also shows that when students think critically while using AI then the learning outcome will also improve. Study also concludes that attitude towards learning strongly and positively moderates the relationship between the use of AI and learning outcomes, it infers that when students have intention to study then there will be a positive relationship between the use of AI and students learning outcome.

Keywords: Use of Artificial Intelligence, Learning Outcomes, Critical thinking, Attitude towards Learning, TRA and TAM.

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Introduction

Research Background

Artificial Intelligence (AI) has emerged as a disruptive technology that has transformed modern society. The era of AI began in the 1950s as an interdisciplinary field, since then it has made significant advancements and discoveries (Grájeda et al., 2024). In the rapidly evolving 21st century, Artificial Intelligence (AI) has emerged as a potent force driving innovation across various sectors (Dhara et al., 2022). Often likened to a powerful weapon like the mythical "Brahmastra" from Hindu scriptures, AI has revolutionized industries ranging from technology and business to healthcare and defense (Chatterjee et al., 2021). Its pervasive influence extends to for-profit and non-profit domains alike, with studies showcasing its transformative impact on healthcare infrastructure (Davenport & Kalakota, 2019; Tekkeşin, 2019) and educational practices (Bates et al., 2020; L. Chen et al., 2020).

Education is the backbone of society. Educational sector has adopted various emerging technologies, among those AI has been extensively leveraged (L. Chen et al., 2020). AI has proven its potential by transforming teaching and learning processes, from elementary level to

higher level, in the field of education (Grájeda et al., 2024). The application of AI in education helps in adopting, learning and providing virtual tutoring to anticipate students' performance, automated administrative tasks, improving educational feedback, enhancing learning experiences and optimize teaching methodologies (Almaiah et al., 2022).

The emergence of artificial intelligence (AI) in education has sparked debates regarding its benefits and risks, particularly in early childhood education (Dhara et al., 2022). While AI offers personalized learning and enhanced accessibility, concerns exist about overuse and misuse. To address these issues, Chen & Lin (2024) proposed the POWER (purposeful, optimal, wise, ethical, responsible) principles to guide AI integration, ensuring its effective and ethical use in education. Further, AI tools and technologies have inspired students to investigate and understand complex concepts, explore enormous ways, develop cognitive thinking and problem-solving abilities (Zhu & Ren, 2022). It encourages students to actively engage in learning by providing interactive simulations, virtual laboratories, and immersive learning experiences (Celik, 2023). AI has proven its potential by transforming teaching and learning processes, from elementary level to higher level, in the field of education (Tsai et al., 2021).

Along with potential benefits, there are also potential drawbacks of AI in the educational sector. It is examined by (Barrios Tao et al., 2019) that dependency of students on AI tools could lead to passive learning mentality among students, in which they depend upon technology to answer and solve questions rather than developing independent thinking skills. Due to the rapid advancement and use of AI in the educational field, there is a need to empirically study the impact of AI on students' intelligence level.

Problem Statement

Despite the rapid advancement and implementation of AI in education, there is still a lack of understanding about the specific effects of AI on students' critical thinking. While some argue that AI can help with cognitive development by providing tailored learning experiences, instant feedback, and personalized challenges, others are concerned about potential drawbacks such as overreliance on AI, reduced critical thinking skills, and a passive approach to learning. Thus, there is a need for comprehensive research into the impact of AI on students' critical thinking and learning outcomes.

Research Question and Objectives

- How does the use of Artificial Intelligence (AI) in education influence students' learning outcome?
- How does critical thinking mediate the impact of the use of Artificial Intelligence (AI) on students' learning outcome?
- How does the 'attitude towards learning' moderate the impact of the use of Artificial Intelligence (AI) on students' learning outcome?
- To explore the impact of the use of Artificial Intelligence (AI) in education on students' learning outcome.
- To investigate the mediating effect of critical thinking on the use of Artificial Intelligence (AI) and students' learning outcome.
- To investigate the moderating impact of the attitude towards learning on the use of artificial intelligence (AI) and students' learning outcome.

Significance of Research

The integration of Artificial Intelligence (AI) in education represents a significant paradigm shift in modern pedagogy, with implications for students' cognitive skills and learning outcomes. Understanding the impact of AI on critical thinking skills and learning outcomes is of paramount importance in shaping educational practices and policies for the future. As AI technologies become increasingly prevalent in classrooms, there is a pressing need to assess their influence on students' cognitive development. This research aims to shed light on whether AI integration enhances or detracts from students' ability to think critically and learn effectively. By investigating this question, educators, policymakers, and stakeholders can gain insights into how best to harness the potential of AI while mitigating potential risks, thereby ensuring that education remains a catalyst for intellectual growth and empowerment in an AI-driven world.

This study dives into the growing role of Artificial Intelligence (AI) in education, aiming to understand how it affects students' thinking skills and academic performance. With AI increasingly used in classrooms, it's important to thoroughly examine its impact. This research seeks to uncover the complex relationship between AI integration and critical thinking abilities, offering insights relevant to educators and policymakers. By exploring the various ways AI influences education, the study aims to highlight both its benefits and potential drawbacks. Through a careful analysis of AI's effects on students' cognitive development and learning outcomes, this research hopes to guide the responsible implementation of AI in education. Ultimately, the goal is to ensure that AI enhances the learning experience without overshadowing students' own intellectual growth and problem-solving skills.

Literature Review

Use of artificial intelligence

Artificial intelligence algorithms are designed to make decisions, often using real-time data (Brundage et al., 2018). They are unlike passive machines that are capable only of mechanical or predetermined responses (Salvagno et al., 2023). Using sensors, digital data, or remote inputs, they combine information from a variety of different sources, analyze the material instantly, and act on the insights derived from those data (Salvagno et al., 2023). Use of AI has been observed in teaching, healthcare, finance, manufacturing and other workplaces (Almaiah et al., 2022).

The growing use of Artificial Intelligence (AI) in education has sparked significant research interest in its learning outcomes (Bates et al., 2020). AI-powered tools and technologies are finding their way into classrooms, promising to personalize learning, improve engagement, and enhance student outcomes (Grájeda et al., 2024). However, the impact of AI on core cognitive skills remains an open question. This study seeks to assess how the use of AI, in its different forms, in education, has impacted or affected different aspects of education (L. Chen et al., 2020). The existing research on Use of AI examines that These AI-powered systems provide personalized instruction, adapting to individual student needs and learning styles (Tsai et al., 2021).

Learning Outcomes

Learning outcomes is the dependent variable of our quantitative research (Tsai et al., 2021). Besides the positive use of Artificial intelligence, it has potential negative consequences on the learning outcomes. Over reliance on AI tools for learning tasks could hinder students'

development of independent learning skills and critical thinking abilities (Celik, 2023). Its excessive focus on pre-defined learning paths and AI-created content stifles creativity and exploration in students (L. Chen et al., 2020).

Research suggests that assessments might prioritize factual recall over deeper understanding (Brundage et al., 2018), and critical analysis (Salvagno et al., 2023). There is a lack of accuracy of information as it generates responses based on patterns in its training data, it lacks a true understanding of the external world (Pedro et al., 2019). This can sometimes result in the propagation of inaccurate or misleading information, which clearly has a detrimental impact on learning. Further, ChatGPT can make learning feel too effortless, as students rely on AI for answers rather than attempting independent problem-solving (Kasneci et al., 2023). Students need to discuss with peers and teachers thin things AI can support but cannot offer (Chatterjee et al., 2021).

Critical Thinking

Critical thinking is the term that is used to describe the competency of an individual (Pithers & Soden, 2000). Critical thinking is the most essential skill in education (Aston, 2023) that is used to identify, analyze and understand the problem, make assumptions, infer it through deductive and inductive logical reasoning and draw conclusions to make effective decisions (Muthmainnah et al., 2022).

In education critical thinking includes how actively and skillfully one can understand, analyze and interpret any data or information (Muthmainnah et al., 2022). In this technological era where AI is at the boom, critical thinking is an essential tool for an individual to become problem solver and effective learner (Thornhill-Miller et al., 2023).

It is concluded by (Aston, 2023; Pithers & Soden, 2000) that educational sectors should involve technological based problem solving and critical thinking activities in their curriculum to develop cognitive skills of the students at all levels (Muthmainnah et al., 2022). It is stated by (Mason, 2007; Thornhill-Miller et al., 2023) that integration of AI in educational sector helps in enhancing and promoting critical thinking ability of the students because AI tools like Chat GPT (Kasneci et al., 2023) and other AI models provide personalized feedback, new learning experiences, and interactive tools that are essential to develop critical thinking (Aston, 2023). On the other hand, (Barrios Tao et al., 2019; Zanetti et al., 2020) argues that depending too heavily on AI techniques may weaken the development of cognitive ability of an individual.

Attitude towards Learning

Attitude towards learning stands as a fundamental component within the Technology Acceptance Model (TAM), a seminal framework introduced by (Davis, 1989). This model elucidates the determinants of user acceptance or rejection of information technology, emphasizing the crucial role of attitude in shaping user behavior (Davis, 1989; Venkatesh & Bala, 2008). Specifically, within TAM, attitude towards learning is conceptualized as an individual's overall evaluation or disposition towards engaging with technological innovations in the learning context (Chai et al., 2021). This attitude is influenced by cognitive beliefs such as perceived usefulness and perceived ease of use, which collectively shape users' intentions and behaviors regarding technology adoption (Ajzen, 2012; Davis, 1989).

As TAM evolved over time, its relevance to understanding user behavior in educational settings persisted, with attitude towards learning remaining a central construct (Kashive et al., 2020). TAM2, an extended version of the original model proposed by (Venkatesh & Davis, 1996), incorporated additional factors while retaining the emphasis on attitude towards learning

in predicting user acceptance of technology. Studies applying TAM principles to e-learning environments, such as (Ignatius & Ramayah, 2005) Course Website Acceptance Model (CWAM), have consistently integrated attitude towards learning as a key determinant of user acceptance and utilization of e-learning platforms.

Conceptual Framework and Hypotheses

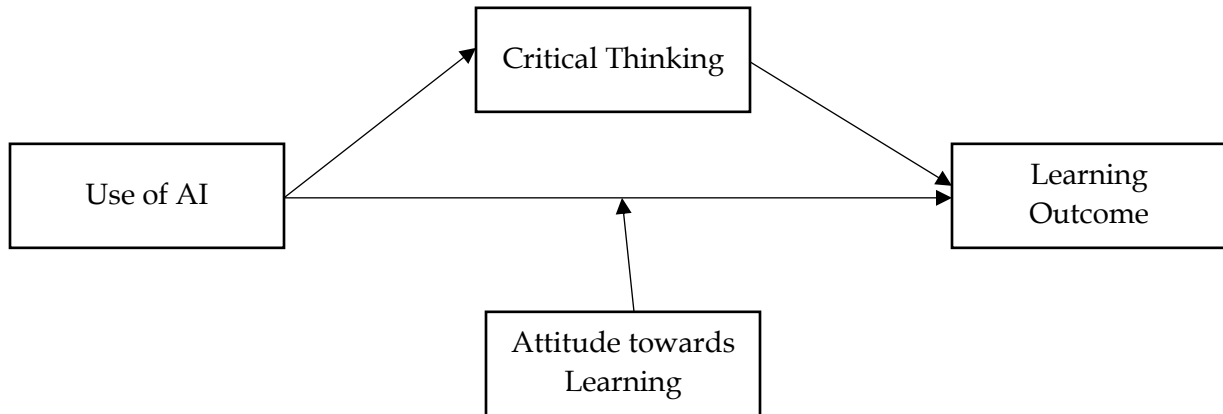


Figure 1: Conceptual Framework

H₁: There is a significant impact of the use of Artificial Intelligence (AI) on students' learning outcome.

H₂: Critical thinking mediates the relationship between the use of Artificial Intelligence (AI) and students' learning outcome.

H₃: Attitude towards learning moderates the relationship between the use of Artificial Intelligence (AI) and students' learning outcome.

Theoretical Underpinning

Integrating the Theory of Reasoned Action (TRA) and the Technology Acceptance Model (TAM) strengthens the theoretical foundation of our framework by taking into account the cognitive and social aspects impacting learners' acceptance and adoption of AI in education (Caldwell & Holloway, 2017; Doll & Orth, 1993). According to TRA, attitudes towards AI use and subjective norms, which are influenced by social pressures and perceived benefits determine learners' intents to participate in AI-mediated learning. TAM goes one step further by emphasizing perceived value and simplicity of use as the main factors influencing attitudes, hence highlighting learners' opinions regarding the usefulness and accessibility of AI tools. This theory, which combines TRA and TAM, offers comprehensive insight into how learners' attitudes, norms, and perceptions interact with critical thinking processes to shape learning outcomes in educational environments enhanced by AI (Ansari et al., 2016; Kamal et al., 2020; Yasir et al., 2021).

Methodology

Research Paradigm

The paradigm of this research is post positivism, as it believes that there is an objective reality which can be measured through empirical studies but it cannot be fully achieved (Panhwar et al., 2017). It used a deductive approach. It involves a quantitative method to collect data, and that data is analyzed and measured using an objective approach. It includes

hypothesis testing which can be accepted or rejected based on the interpretation of the data (Panhwar et al., 2017).

Research Strategy

Type of Research

The study employs a quantitative research methodology to investigate the relationship between the use of artificial intelligence (AI), learning outcomes, and critical thinking, with a focus on the moderating role of learning outcomes (Kashive et al., 2020). The independent variable (IV), use of artificial intelligence, will be operationalized as the extent to which AI technologies, such as intelligent tutoring systems or personalized learning platforms, are integrated into the educational environment (L. Chen et al., 2020). The dependent variable (DV), learning outcomes, will be measured using objective assessments of students' knowledge acquisition, skill development, and academic performance (Tsai et al., 2021). Critical thinking will serve as the mediator variable, reflecting students' ability to analyze information, evaluate arguments, and make reasoned judgments (Thornhill-Miller et al., 2023). The moderating role of learning outcomes will be explored to understand how the relationship between the use of AI and critical thinking may vary depending on students' overall academic achievement (Chai et al., 2021).

Types of Variables

Independent and dependent are the two types of variables. The independent variable of this research is use of Artificial Intelligence whereas the dependent variable of this research is learning outcomes.

Research Design and Population

This research is a cross sectional in nature (Weidener & Fischer, 2024). The target population of this study is the students who use AI tools for solving critical problems and integrate AI as their par of learning.

Sample Technique and Sample Size

The data will be collected from immediately available students based on convenience sampling (Crossman, 2020; Tongco, 2007). Previous research used the empirical studies to test hypotheses and used the sample size of 250 participants (Chen & Lin, 2024). Based upon prior studies the sample size of our research is 250 participants, that is an appropriate sample size (Hair et al., 2010).

Data Analysis

This chapter shows the analysis and interpretation of the data which was collected from our respondents through questionnaires. The analysis and interpretation of the data is based upon the result of the questionnaire.

Respondents Profile

Table 1: Respondent's profile

Demographics		Number	Percentage (%)
Gender	Male	23	44.2
	Female	29	55.8

Demographics		Number	Percentage (%)
Age	Less than 20	5	9.6
	21 to 25	19	36.5
	26 to 30	19	36.5
	31 to 35	7	13.5
	36 to 40	1	1.9
	41 to 45	1	1.9
Qualification	Matriculation	1	1.9
	Intermediate	6	11.5
	Bachelors	30	57.7
	Masters	12	23.1
	M.Phil	3	5.8
Are you aware of AI	Yes	48	92.3
	No	4	7.7

There are 23 (44.2%) male and 29 (55.8%) female respondent. 19 respondents lie in age bracket of 21 to 25 years (36.5%) and 26 to 30 (36.5%). 30 (57.7%) of the respondents have bachelor’s degree, 12 (23.1%) have master’s degree and 3 (5.8%) respondents have M.Phil. degree. 48 (92.3%) respondents are aware of AI, whereas, only 4 (7.7%) respondents are not aware of AI.

Descriptive Statistics

In the below Table 3, learning outcome is there with the highest Skewness (M=3.38, SD=1.191) with the value of -.585 while its Kurtosis is -.495. This is followed by critical thinking (M=3.46, SD= 1.163) with the value of -.604 while its Kurtosis is -.100. Further followed by use of AI (M=3.50, SD=1.260) with the value of -.611 while its Kurtosis value is -.411. The lowest among all is attitude towards learning (M=3.52, SD=1.038) with the value of -.873 while its Kurtosis value is .759.

Table 2: Descriptive Statistics

Constructs	Mean	SD	Skewness	Kurtosis
Attitude towards learning	3.52	1.038	-0.873	0.759
Use of AI	3.50	1.260	-0.611	-0.411
Learning Outcome	3.38	1.191	-0.585	-0.495
Critical thinking	3.46	1.163	-0.604	-0.100

Reliability Analysis

Table 3: Reliability Analysis

Constructs	Mean	SD	Cronbach’s Alpha
Attitude towards learning	3.52	1.038	0.811
Use of AI	3.50	1.260	0.899
Learning Outcome	3.38	1.191	0.839
Critical thinking	3.46	1.163	0.830

The Cronbach’s alpha value of use of AI is the highest (M=3.50, SD=1.260) with the value .899, followed by learning outcome (M=3.38, SD=1.191) with alpha = .839. Further, followed by critical thinking (M=3.46, SD=1.163) with alpha = .830. The lowest value for Cronbach alpha is .811 for attitude towards learning.

Regression analysis

The results depict independent variable use of AI explains 69% variance (R²=0.699, F (1, 52) = 116.303, p<0.05) on learning outcomes. It is also found that use of AI (β=0.790, p < 0.05) significantly positively influences learning outcomes.

Table 5 Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.619	.272		2.274	.027
	UseofAI	.790	.073	.836	10.784	.000
Dependent variable: Learning outcome, R2 = 0.699, Adjusted R2 = 0.531, F(1, 52) = 116.303, p < 0.05						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.376	.308		1.224	.227
	Use of AI	.706	.089	.747	7.906	.000
	Critical Thinking	.156	.097	.152	1.608	.114
Dependent variable: Learning outcome, R2 = 0.714, Adjusted R2 = 0.703, F(1, 52) = 61.288 p < 0.05						

Mediation Analysis

Table 6: Mediation Analysis

Effect	SE	T	P	LLCI	ULCI
Total Effect of X on Y					
.7901	0.733	10.7844	.0000	.6430	.9373
Direct Effect of X on Y					
.7056	.0892	7.9064	.0000	.5236	.8850

The model aims to explore the mediating role of critical thinking in the relationship between use of AI and learning outcome. The regression of use of AI with learning outcome, ignoring the mediator was significant ($p < 0.05$) ($R^2 = 0.699$ Strong model). Secondly, the model showed that the regression of use of AI with mediation effect of perceived value was also significant. ($p < 0.05$) ($R = 0.7668$, Strong model). The mediation model showed the mediator (critical thinking) and independent variable (use of AI) both are significant. P value of mediator is ($0.0001 < 0.05$) whereas the p value of the independent variable is ($0.0000 < 0.05$). A Sobel test was conducted and found full mediation in the model. It was found that critical thinking fully mediated the relationship between use of AI and learning outcome ($p < 0.05$ i.e. 0.0001).

Moderation Analysis

Table 7: Conditional effect of X on Y at values of the moderator

ATL	Effect	se	t	p	LLCI	ULCI
2.4809	.4042	.1109	3.645	.0007	1813	.6272
3.5192	.4704	.0866	5.4355	.0000	.2964	.6445
4.5575	.5367	.0963	5.5728	.0000	.3430	.7303

The model aims to explore the moderating role of attitude towards learning in the relationship between use of AI and learning outcome and the significance is clearly seen in the above table.

Conclusion and Recommendation

This research investigated the impact of Artificial Intelligence (AI) on students' learning outcomes through the mediation effect of critical thinking and moderating effect of attitude towards learning. The findings suggest a strong positive relationship that with increased use of AI, learning outcomes tend to improve which was highlighted and supported by prior studies (Barrios Tao et al., 2019). The study also shows that when students thinks critically while using

AI then the learning outcome will also improve (Mason, 2007). Study also concludes that attitude towards learning strongly and positively moderates the relationship between the use of AI and learning outcomes, it infers that when students have intention to study then there will be the positive relationship between the use of AI and students learning outcome (Chai et al., 2021). However, the research acknowledges the need for further exploration of the mechanisms behind this relationship and potential confounding variables.

Limitations

The study acknowledges several limitations. Firstly, the research employed a cross-sectional design, limiting the ability to establish causality between the use of AI and learning outcomes. Further, the study relied on a convenience sample, potentially affecting the generalizability of the findings. Additionally, the research focused solely on self-reported data through questionnaires, which might be susceptible to bias.

Recommendations

Utilizing more diverse and representative samples would enhance the accuracy of the findings. Incorporating objective measures of learning outcomes beyond self-reported data can strengthen the research. Moreover, exploring the potential influence of factors like student characteristics and instructional design on the interaction between AI and critical thinking skills is recommended. Finally, investigating potential negative consequences of AI overuse on critical thinking and developing strategies to mitigate these risks are valuable areas for further research.

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