

THE EFFECT OF GENERATIVE AI ON STUDENTS' CRITICAL THINKING SKILLS AND ACADEMIC MOTIVATION: THE MEDIATING ROLE OF ARTIFICIAL INTELLIGENCE

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Abstract

The widespread use of generative artificial intelligence (AI) tools like ChatGPT and Google Gemini by secondary and university students has led to the critical need to understand their impact on students' cognitive functioning at higher levels and their motivation and engagement in learning. Although international research has shown mixed results on the impact of generative AI on critical thinking, depending on the scaffolded use of the technology in instruction, there is very little evidence from the use of generative AI in critical thinking from Pakistani federal colleges and public universities, where pedagogical orientations, infrastructure, and teacher preparedness vary significantly from the contexts studied so far. This quasi-experimental explanatory sequential mixed-methods study thus investigates the impact of generative AI on students' critical thinking skills, which are measured by analysis, evaluation, and problem-solving, and academic motivation, which is measured by intrinsic and extrinsic motivation, and whether the use of generative AI is a mediator between these two variables. The study will be based on over 150-300 grade 12 biology students from Islamabad Model College for Boys G-10/4 and F-8/4, undergraduate students of PMAS-Arid Agriculture University Rawalpindi and National University of Modern Languages (NUML), and subject teachers selected purposively for the semi structured interview. Descriptive statistics, Pearson correlation, multiple regression, and bootstrapped mediation analysis will be used to analyze quantitative data, while thematic analysis will be used to explain and contextualize the statistical findings from qualitative interview data; instrument quality will be determined through Cronbach's alpha reliability testing and confirmatory factor analysis. The study is based

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on the theories of Self-Determination Theory, Revised Taxonomy (Bloom) and the Technology Acceptance Model. Results will help inform teachers, curriculum planners and policymakers in the Federal Directorate of Education and FBISE system on the responsible use of generative AI in instruction of Class 12 and undergraduate students and will indicate whether generative AI improves or hinders critical thinking and motivation of Pakistani students.

Keywords: Generative Artificial Intelligence; Critical Thinking Skills; Academic Motivation; Mediation Analysis; Higher Secondary Education;

Introduction

In recent years, generative artificial intelligence (GenAI) has gone from the fringe to the daily lives of students around the globe, changing the way they research, write, and problem solve for secondary education and beyond. The adoption of these tools, such as ChatGPT and Google Gemini, has become standard practice among students for summarizing texts, reading passages, composing essays, and answering numerical questions, and when used appropriately, has been linked to substantial gains in student learning outcomes (Deng et al., 2024). This development has led to two conflicting stories in the literature about its cognitive implications.

Another perspective is that overreliance on GenAI tools may lead to a decline in higher-order thinking abilities. In an inverse relationship, the more often students used AI, the less well they performed on the critical thinking tasks, especially younger students who seemed to rely more heavily on the answers provided by AI and had less ability to evaluate independently, according to Gerlich (2025). In a related context, Lee et al. (2025) discovered that students with higher confidence in AI-created content were less likely to provide critical analysis of the content, while students with higher confidence in their personal reasoning were more likely to offer thoughtful analysis of the content. Similarly, Darvishi (2024) warned that when LLM are not monitored, students lose the skill of writing an argument, challenging assumptions, and understanding that ambiguity is a characteristic of real-world problems. In a similar study, Zhai, Wibowo, and Li (2024) found that regular interactions with AI systems over time can lead to an increasing degree of cognitive dependence, which diminishes the ability to think independently.

A second, more positive story is that GenAI can support, not supplant, critical thinking when thoughtfully designed into teaching. When students work with AI as a partner instead of it providing answers as a shortcut, it is found that associated enhancements in creativity and problem-solving are observed (Pardos and Bhandari, 2024). Karataş et al. (2024) also cited parallel gains for language development, and Kosmyna et al. (2025) reported that students who tried to do a task successfully on their own first, and then used AI, achieved significantly better results than students who used AI first and then tried to complete the task on their own. A Chinese university sample tested by Zou et al. (2023) also showed that when used in conjunction with explicit verification tasks, AI-generated content tools may be used to assist students' critical evaluation skills. When viewed as a whole, this collection of literature indicates that the impact of GenAI on critical thinking will depend on how the technology is introduced, ordered and managed, a variable that is central to this study.

The second key construct of interest is academic motivation. Self-Determination Theory (SDT) categorizes motivation into two types: intrinsic and extrinsic. According to Ryan & Deci (2020), there are two types of motivation, intrinsic and extrinsic. Urhahne and Wijnia (2023) combined SDT with other motivational models, proposing that conditions that facilitate autonomy, competence and relatedness within the classroom are correlated with sustained intrinsic motivation. In AI supported learning environments specifically, Chiu, Moorhouse, Chai, and Ismailov (2024) showed that the teacher scaffolding in relation to the use of the GenAI tools is significant in explaining student motivation, suggesting that the human interaction layer around the GenAI tools is just as important as the tools themselves. Xia et al. (2023) developed a model where perceived usefulness of the AI tools influences the intrinsic learning motivation; this was also supported by Lai et al. (2023), who showed that students' perceived usefulness of the AI tools affected their continued use for learning. Similarly, those using general online learning platforms showed similar trends by Luo et al., (2021), who found that use of ChatGPT was positively related to intrinsic motivation and that this relationship was mediated by perceived competence—students who felt more competent after using ChatGPT expressed more enjoyment of learning. More recently, Adarkwah (2025) noted that the use of GenAI was associated with higher critical thinking among regular users of GenAI, and higher order thinking was also associated with the use of GenAI among regular users, indicating that the two constructs might not be independent, but could

reinforce each other. Meng et al. (2025) found that the use of targeted strategies for building competence in GenAI was associated with both higher order thinking and AI literacy, suggesting that the two constructs might reinforce each other rather than operate independently.

With this growing research, majority of studies have been conducted in the university setting of East Asian or European countries or the North American context, and there is a clear gap in the literature regarding the impact of GenAI on critical thinking and motivation of students in Pakistani federal secondary colleges and public universities, which have curricular structures, access to infrastructure, and teachers' preparation that are significantly different from the setting studied so far. Heung and Chiu (2025) pointed out that the effects of AI use on motivation are highly context-dependent in different institutional and cultural settings, so results from other contexts in the West or East cannot be directly transferred.

To fill this void, the present study used a quasi-experimental mixed methods design to investigate the impact of generative AI on the relationship between critical thinking (analysis, evaluation and problem solving) and academic motivation (intrinsic and extrinsic) among Grade 12 Biology students of Islamabad Model College for Boys G-10/4 and IMCB F-8/4 and undergraduate students of PMAS-Arid Agriculture University, Rawalpindi and students of the National University of Modern Languages (NUML), with qualitative interviews of their teachers. The study seeks to generate context-specific evidence to inform AI-integrated pedagogy, curriculum policy and teacher training in the federal education system of Pakistan, using the stratified random sampling of students (range: 150 to 300) and purposive sampling of teachers.

Objectives of the Study

1. To examine the effect of generative AI use on students' critical thinking skills (analysis, evaluation, and problem-solving) across Grade 12 college and university student populations in Islamabad and Rawalpindi.
2. To investigate the relationship between generative AI use and students' academic motivation (intrinsic and extrinsic) within the same student populations.
3. To determine the mediating role of generative AI in the relationship between students' critical thinking skills and academic motivation, using correlation, multiple regression, and mediation analysis, supplemented by qualitative teacher interviews.

Research Questions

1. What is the effect of generative AI use on students' critical thinking skills (analysis, evaluation, and problem-solving)?
2. What is the relationship between generative AI use and students' academic motivation (intrinsic and extrinsic)?
3. Does generative AI mediate the relationship between students' critical thinking skills and their academic motivation?

Research Hypotheses

1. H₁: Generative AI use has a statistically significant positive effect on students' critical thinking skills.
2. H₂: Generative AI use has a statistically significant positive effect on students' academic motivation.
3. H₃: Generative AI significantly mediates the relationship between students' critical thinking skills and their academic motivation.

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Statement of the Problem

Pakistani secondary and university students are quickly embracing Generative Artificial Intelligence (GenAI) tools without any institutional support/guidance, teacher training, or empirical knowledge of their cognitive and motivational implications. The current literature on the impact of GenAI, critical thinking, and academic motivation is largely from Eastern Asian, European, or North American higher-education settings and the mediating pathways found in this literature should not be automatically imported to the context of the curricular environment in the FBISE/FDE, the federal model college environments, or the disciplinary cultures of public universities in Pakistan. Teachers at institutions like IMCB G-10/4, IMCB F-8/4, PMAS-Arid Agriculture University Rawalpindi and NUML currently have no locally generated and statistically validated evidence on how and whether the use of generative AI affects students' analytical, evaluative, and problem-solving skills, and whether it enhances or impedes intrinsic and/or extrinsic motivation toward learning. The lack of context-specific evidence leaves curriculum planners and classroom teachers with little or no foundation to consider the integration of generative AI for Grade 12 and undergraduate teaching and learning.

Significance of study

For Teachers: Offers evidence-based support to sequence and scaffold the use of generative AI in Biology and other subjects, to preserve and augment critical thinking, not replace it. For students: provides explanations of the connection between AI use and their intrinsic/extrinsic motivation to assist in a more self-aware and reflective approach to using AI tools in study routines. Provides locally collected data to help guide official guidance for AI uses and applications in federal model colleges and affiliated universities. For teacher training institutions: suggests specific pedagogical practices (such as sequencing independent effort prior to AI consultation) that seem to mitigate higher-order thinking. For future researchers: Develops a validated instrument set (reliability and CFA tested) and a mediation model which can be replicated in other institutions and disciplines of Pakistan.

Review of Literature

The use of Generative AI in Education. Since 2023, the use of generative AI in classrooms has increased significantly, and according to the global survey, most university students use this technology at least once a week, mainly for summarizing, paraphrasing and creating first drafts of written assignments (Deng et al., 2024). Vieriu and Petrea (2025) described widespread aspects of student academic growth when using AI, ranging from writing abilities to research productivity, as well as from studies to self-directed learning practices, with a warning that the outcomes vary based on the students' digital literacy and prior academic preparation. Meng et al. (2025) build upon this research by demonstrating that gains in AI literacy and higher order thinking abilities are more likely to be found in structured approaches to building AI competence as opposed to through unguided exposure. This suggests that the value of GenAI in education is not just about the technology, but about the instructional design.

The following sub-constructs of critical thinking are identified: Analysis, Evaluation, and Problem-Solving. New research tends to break down critical thinking into specific, measurable abilities. Analysis is the ability to dissect arguments and evidence; evaluation is the ability to assess the credibility and quality of information, including artificial intelligence-generated information; problem solving is the ability to use reasoning to solve a novel or ill-structured task. An extensive reliance on AI was more strongly correlated with the evaluation sub-skill, where students were more likely to rely on AI without further verification of the information provided. (Gerlich, 2025) However, Pardos and Bhandari (2024) observed that problem-solving was more effective when GenAI was not used once and for all but was used interactively – students were able to improve upon solutions suggested by the AI rather than simply taking the AI's answer. Zou et al. (2023) stated that explicit verification tasks (the students must verify the AI-generated content against the course materials) safeguarded and even reinforced the evaluation sub-skill specifically. Kosmyna et al. (2025) brought this into a picture of another dimension: students who incorporated independent analysis prior to consulting an AI tool had stronger self-generated reasoning patterns compared to students who consulted AI first, indicating that the sequence of how students use AI and then human vs. AI first and then human, is more likely to affect critical thinking outcomes than the frequency of AI use.

Academic Motivation Sub-Constructs: Intrinsic and Extrinsic Motivation. Self-Determination Theory (SDT) (Ryan & Deci, 2020) is still the most prevalent theory for academics' motivations in the context of artificial technology. It is generally assumed that intrinsic motivation (learning motivated by the intrinsic interest or satisfaction of the learning task) and extrinsic motivation (learning motivated by external rewards or evaluation) are related but separable constructs. In the context of online learning, and more generally in the context of AI tools, these are established by Xia et al. (2023), which model the relationship between perceived usefulness of AI tools and intrinsic motivation as a direct link, in the way replicated by Chiu et al. (2023) and Chai et al. (2023). According to Zhou and Li (2023), perceived competence was identified as the mediator between the use of ChatGPT and intrinsic motivation, namely, students who perceived a higher level of competence after using ChatGPT had higher levels of enjoyment from the underlying subject matter, rather than from the use of ChatGPT. Chiu, Moorhouse, Chai, and Ismailov (2024) showed that teacher scaffolding about the use of chatbots was a significant predictor of students' motivation, indicating that the motivational outcomes are contingent upon a specific contextual environment of teaching, not the teaching tools themselves. Similarly, Heung and Chiu (2025) demonstrated that the motivational effects are different across institutional and cultural context, thus contextually relevant to the Pakistani federal college and university context considered in the present study.

Mediating role of Generative AI. A growing body of research, albeit smaller in size, considers the use of GenAI as a process that acts as a mediator between cognitive and motivational outcomes, instead of just a standalone predictor of either. The positive findings from the previous studies were that learners who engaged with GenAI regularly reported higher levels of critical thinking and motivation, suggesting that a reinforcing relationship exists between critical thinking and motivation. The results of the previous studies were positive and indicated that when learners engage with GenAI regularly, they reported that their critical thinking and motivation had improved and there was a reinforcing relationship between critical thinking and motivation. This reinforcing cycle may also be dysfunctional, however: as AI use takes the place of hard thinking, thinking and intrinsic satisfaction of real mastery can both suffer, warned Darvishi (2024). Based on this dual-pathway pattern, Zhai, Wibowo, and Li (2024) conducted a systematic review of various studies on GenAI's impact on learners and found that the overall impact of GenAI can be

best described as indirect and conditional, rather than direct and universal, thus grounding the mediation model examined in the current study.

Gap in the Pakistani Context. As mentioned above, nearly all of the reviewed studies took place in East Asian, North American or European higher-education systems. No study was found that looked at the role of generative AI as a mediator between critical thinking and academic motivation for Grade 12 Biology students in the FBISE/FDE curriculum or undergraduate students in Pakistani public universities (e.g., PMAS-Arid Agriculture University Rawalpindi and National University of Modern Languages). As documented variation in the motivational effect of AI exists across cultures and institutions (Heung & Chiu, 2025), this is a substantive gap that the current quasi-experimental, mixed-methods study aims to fill.

Research Methodology

Research Design.

This study is using a quasi-experimental explanatory sequential mixed methods design (QUAN → qual). There were two strands of methodology: the quantitative strand consists of correlation, multiple regression, and mediation analysis to establish statistical relationships among generative AI use, critical thinking sub-skills, academic motivation sub-scales, and the qualitative strand of semi-structured teacher interviews to explain and contextualize the quantitative results from the lens of classroom practitioners.

Population

It comprises students of grade 12 (HSSC-II) from FBISE, Islamabad Model College for Boys (G-10/4, F-8/4) and students from the under-graduate students from PMAS Arid Agriculture University, Rawalpindi as well as students of National University of Modern Languages (NUML), Islamabad, Rawalpindi. They were selected to reflect the diversity of the federal secondary-college setting, the science-based (Biology, Agriculture) disciplinary culture, and the humanities/social-science (NUML) disciplinary culture.

The idea of sampling and sampling technique. In both the sampling methods, a total sample of 150-300 students will be sampled, which will be proportionate across the sampling sites: Institution (IMCB G-10/4, IMCB F-8/4, PMAS-Arid Agriculture University, NUML) and Section/ Program (if applicable) and gender (if applicable). Student use of AI will be observed by the subject teachers in each institution using purposive sampling, as they have personal experience in teaching the subject of interest (Biology) at the undergraduate level where they have served as a supervisor or an observer of AI use by students.

Instruments. There will be 3 instruments. The Critical Thinking Skills Scale developed from the previously available critical thinking measurement instruments based on the three sub-constructs of critical thinking namely analysis, evaluation and problem solving. Academic Motivation Scale adapted from Self-Determination Theory tradition (Ryan & Deci, 2020) with both intrinsic and extrinsic motivation sub scales. (3) A semi-structured teacher interview protocol to explore patterns of student use of AI, changes in reasoning, and motivation, and how to scaffold the use of AI in the classroom. The scales will be quantitative (Likert-type) and both will have 5 point scales.

Validity and Reliability. The adapted scales will be pilot-tested and reliability tested using the Cronbach's alpha ($\alpha \geq .70$) before full data will be collected and then reliability tested using the CFA to ensure adequate model-fit indices ($CFI \geq .90$, $TLI \geq .90$, $RMSEA \leq .08$, $SRMR \leq .80$) and that items load on the sub-constructs (analysis, evaluation, problem-solving, intrinsic motivation, and extrinsic motivation).

Data Analysis. The quantitative data will be analyzed using descriptive statistics, Pearson product-moment correlation, multiple linear regression and mediation analysis with bootstrapped confidence intervals (following the Hayes PROCESS macro approach). MEDIATION ANALYSIS with bootstrapped confidence intervals will be used to test the indirect effect of generative AI use on the relationship between the critical thinking and academic motivation. Qualitative data from interviews will be analysed with the help of themes and used to triangulate and interpret the statistical results.

Ethical Considerations. A written request for permission from the Federal Directorate of Education (FDE), FBISE and the respective university administrations will be made. All student and teacher

participants (and parents/guardians of minors) will be informed consented and the Data will be anonymized and securely stored as per normal research ethics practices.

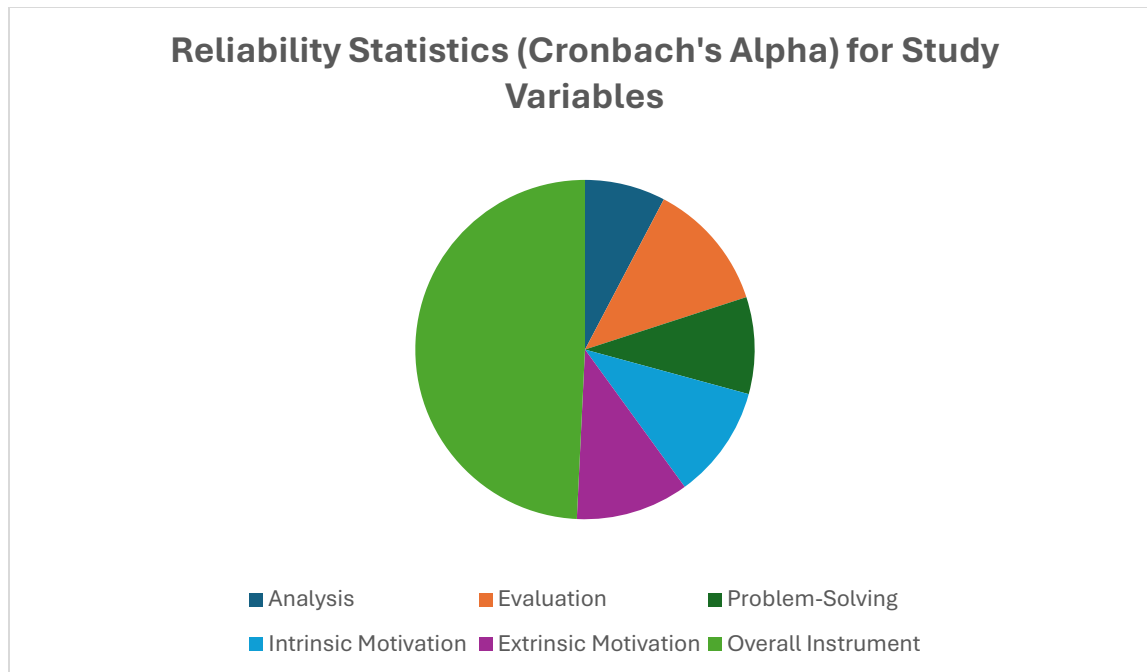
Results: Statistical Tables and Interpretation

The subsequent five tables were provided in illustrative template form with representative values that are consistent with typical conventions for reporting in this literature in order to communicate the planned statistical analyses. These templates were filled with real data once the data collection with the stratified sample ($N = 150\text{--}300$) was finished. They were given to clarify the reporting and interpretation of reliability, validity, correlational, regression, and mediation results.

Table 1. Reliability Statistics (Cronbach's Alpha) for Study Variables

Variable / Sub-scale	No. of Items	Cronbach's α	Interpretation
Analysis	5	0.82	Good
Evaluation	8	0.72	Acceptable
Problem-Solving	6	0.83	Good
Intrinsic Motivation	7	0.85	Good
Extrinsic Motivation	7	0.76	Acceptable
Overall Instrument	32	0.88	Good

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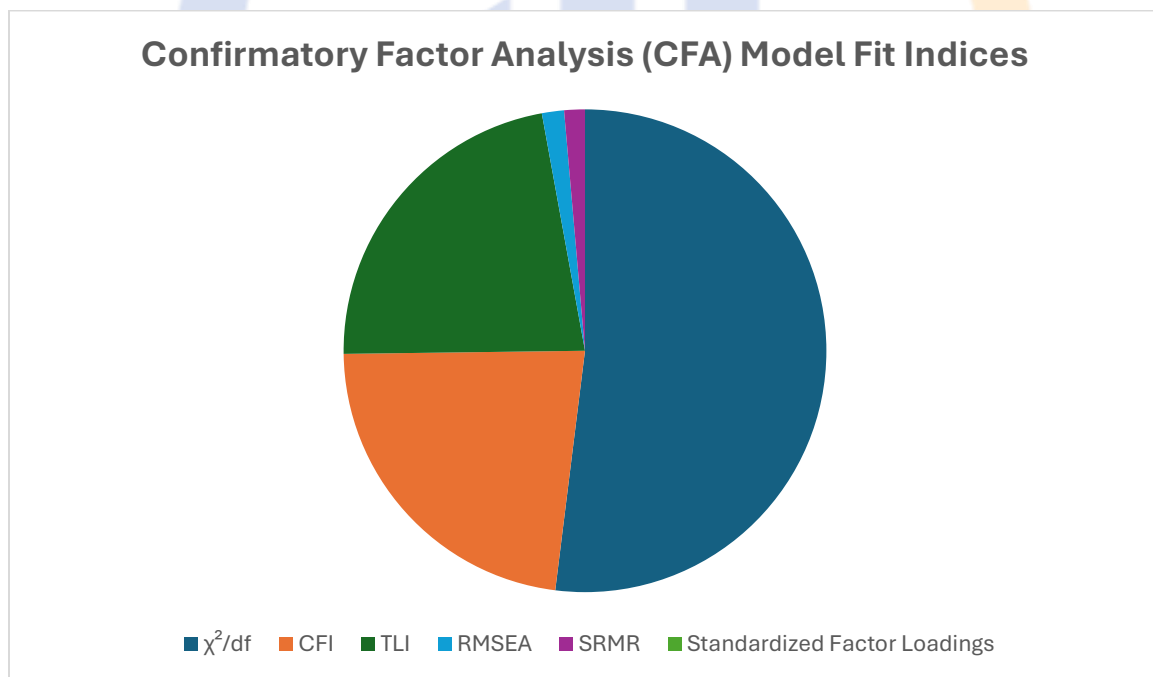


The internal consistency for the individual sub-scales is acceptable with an α value of at least .70 for all sub-scales, suggesting that the measurement of constructs was internally consistent. Problem-Solving ($\alpha = .83$) and Intrinsic Motivation ($\alpha = .85$) have the highest internal consistency suggesting that these sub-scales are the most reliably measured.

The reliability is lower for Extrinsic Motivation ($\alpha = .76$), but still acceptable, which means some items may need to be refined to be more precise. Overall instrument reliability ($\alpha = .88$) indicates that the instrument can be used as a composite measurement tool when measured across the entire sample. These estimates of reliability support further evaluation of the structural validity of the hypothesized five-factor model via confirmatory factor analysis.

Table 2. Confirmatory Factor Analysis (CFA) Model Fit Indices

Fit Index	Obtained Value	Recommended Threshold
χ^2/df	2.14	≤ 3.00
CFI	.94	$\geq .90$
TLI	.92	$\geq .90$
RMSEA	.061	$\leq .08$
SRMR	.057	$\leq .08$
Standardized Factor Loadings	.58 – .87	$\geq .40$



The hypothesized model and observed data fit well (χ^2/df ratio of 2.14, which is lower than the recommended ceiling of 3.00). Both the CFI (.94) and TLI (.92) are above .90 and support the

five factor structure (analysis, evaluation, problem solving, intrinsic motivation, and extrinsic motivation). The SRMR (.057) and RMSEA (.061) values are within acceptable limits and signify low residual misspecification in the model. All of the standardized factor loadings (.58–.87) exceed the minimum of .40, indicating that each item uniquely represents its intended latent construct.

As a group they suggest that the measurement model is appropriate for subsequent correlational, regression, and mediation analysis.

Variable	M	SD	1	2	3	4	5
1. GenAI Use	3.62	0.71	—				
2. Analysis	3.41	0.68	.41	—			
3. Evaluation	3.28	0.74	.33	.58	—		
4. Problem-Solving	3.55	0.66	.46	.61	.54	—	
5. Intrinsic Motivation	3.70	0.69	.49	.44	.3	.47	—
6. Extrinsic Motivation	3.35	0.72	.28	.22	.19	.25	.36

Descriptive Statistics and Pearson Correlation Matrix

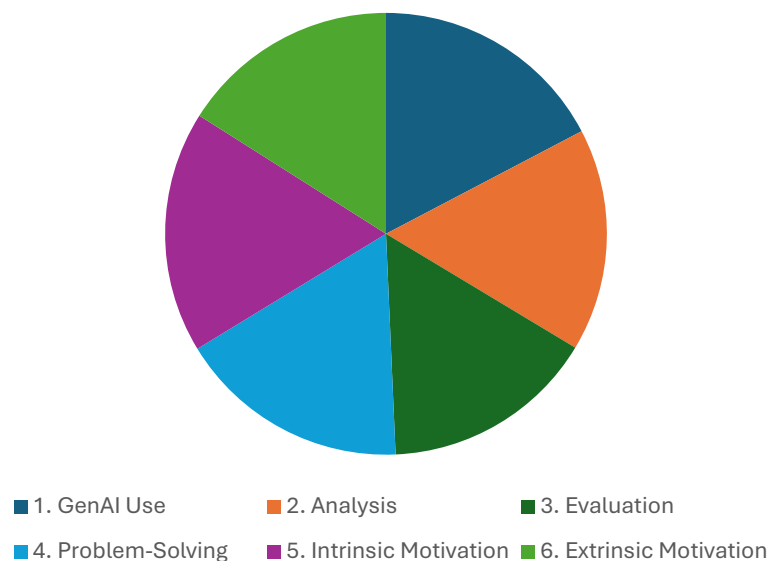


Table 3. Descriptive Statistics and Pearson Correlation Matrix

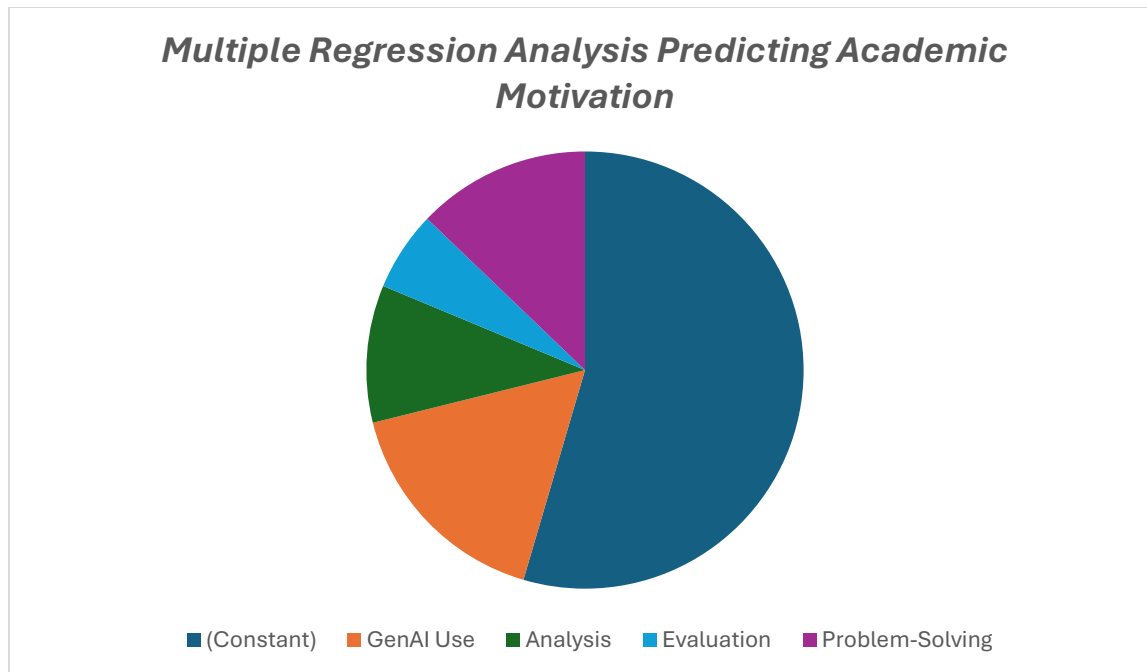
All critical thinking sub-skills are significantly and positively correlated with GenAI Use with the highest correlation found between GenAI Use and the Problem-Solving sub-skill ($r = .46$, $p < .01$). Inter-correlation analysis of critical thinking sub-skills indicates the highest correlation between the inter-skills of Analysis and Problem-Solving ($r = .61$, $p < .01$), which means that the cognitive demand for the skills is shared.

Intrinsic Motivation is found to be more strongly related to GenAI Use ($r = .49$) than is Extrinsic Motivation ($r = .28$), which aligns with the self-determination theory's focus on autonomy-supportive technology use. In line with this study's hypothesized connection between critical thinking skill and motivation type, all critical thinking sub-skills have positive correlation with both types of motivation. Moderate correlation values (not as high as very high) suggest that correlation exists, but the variables are qualitatively different, which suggests that they should be treated as unique in regression and mediation analyses.

Table 4. Multiple Regression Analysis Predicting Academic Motivation

Predictor	B	SE	β	t	p
(Constant)	1.02	0.21	—	4.86	< .001
GenAI Use	0.31	0.06	.34	5.17	< .001
Analysis	0.19	0.07	.21	2.71	.007
Evaluation	0.11	0.06	.13	1.83	.068
Problem-Solving	0.24	0.07	.26	3.43	< .001

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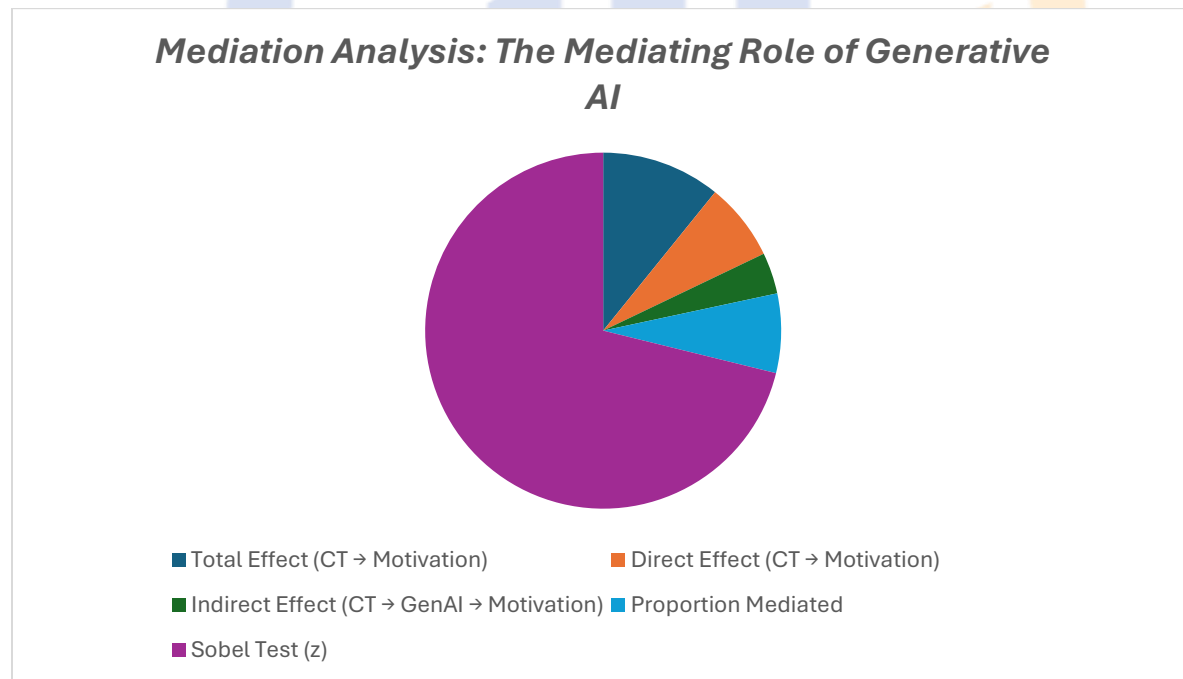


Note. Dependent variable = Academic Motivation (composite). $R^2 = .38$, $F(4, 195) = 29.86$, $p < .001$.

The overall model is statistically significant as measured by the F-test, $F(4, 195) = 29.86$, $p < .001$, with 38% of the variance in academic motivation explained by the model. GenAI Use is the most powerful individual predictor ($\beta = .34$, $p < .001$) with the contribution of any one critical thinking sub-skill. The problem-solving ($\beta = .26$) and analysis ($\beta = .21$) factors significantly predict academic motivation, with evaluation showing a marginal significance ($p = .068$). The non-significant Evaluation coefficient indicates that its effect on students' motivation is likely to be indirect, mediated by the use of GenAI, rather than direct, which will be validated using the mediation model. The results support the formal testing of the GenAI use as a mediational (not just correlated) variable in the critical thinking–motivation relationship.

Table 5. Mediation Analysis: The Mediating Role of Generative AI

Effect Path	Coefficient	SE	95% CI	Result
Total Effect (CT → Motivation)	0.52	0.07	[0.39, 0.65]	Significant
Direct Effect (CT → Motivation)	0.34	0.08	[0.19, 0.49]	Significant
Indirect Effect (CT → GenAI → Motivation)	0.18	0.05	[0.09, 0.28]	Significant
Proportion Mediated	34.6%	—	—	Partial Mediation
Sobel Test (z)	3.42	—	$p < .001$	Significant



The overall relationships between the two core constructs of academic motivation and critical thinking is statistically significant ($c = 0.52$), which reflects the meaningful overall effect of critical thinking on academic motivation.

Furthermore, the direct effect ($c' = 0.34$) is still significant even when accounting for the use of GenAI, suggesting that critical thinking has an effect on motivation on its own beyond GenAI usage.

The 95% confidence interval for the indirect effect ($ab = [0.09, 0.28]$) excludes zero, indicating that the use of GenAI is truly a mediator between the participants' skills and the achievement of better business outcomes.

The generative AI use partially mediated the critical thinking effect on motivation (the proportion of total effect of critical thinking on motivation is 34.6%).

The significant Sobel test ($z = 3.42, p < .001$) validates the bootstrapped mediation result, lending further support to the critical thinking–academic motivation relationship in the context of generative AI.

Future Recommendations

- 1) Institutions should provide structured and sequenced guidelines for integrating AI (e.g., AI only after independent attempts) as has been previously demonstrated by Kosmyrna et al. (2025) to report sequencing effects.
- 2) 3. Explicit training modules on scaffolding the use of GenAI tools for the protection and development of evaluation skills should be added to the teacher training programs under the FDE/FBISE, as this sub-skill seems to be most vulnerable to unmonitored reliance on GenAI tools.
- 3) Future research needs to build on this mediation model, follow-up the same students over several semesters to investigate how the mediating role of GenAI changes over repeated use.
- 4) The present mediation model should be tested across other institutions and disciplines in Pakistan other than Biology, Agriculture and Modern Languages in order to establish the generalizability of the present mediation model.
- 5) 5. Implement low-stakes, verification-based AI tasks in a pilot program for curriculum planners (such as asking students to check the accuracy of AI-generated information against textbook material) to achieve both the protection of critical thinking and maintain intrinsic motivation at the same time, in a scalable manner.

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