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Explore the role of Artificial Intelligence on Students' Critical Thinking and Problem-Solving Skills at higher Education Institution in Pakistan

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Abstract

The rapid integration of artificial intelligence (AI) into higher education is reshaping how students approach learning, with growing attention on its implications for critical thinking. This study examines the perceptions of undergraduate students from public sector universities in Punjab, Pakistan regarding the influence of AI tools on their critical thinking skills. Using a **quantitative, descriptive design**, data were collected from a stratified random sample of 300 students through a **self-developed Likert-scale questionnaire** focusing on AI usage patterns, perceived cognitive impact, and ethical considerations. Validity was ensured through expert review, and reliability testing yielded a Cronbach's Alpha of 0.87, indicating strong internal consistency. Descriptive statistics, independent t-tests, ANOVA, and correlation analyses were employed using SPSS v26. Results showed that students generally perceive AI as enhancing synthesis, evaluation, and analysis skills, with **education faculty students reporting higher positive perceptions** compared to those from natural sciences. No significant gender differences were observed. However, concerns about **overreliance on AI and ethical dilemmas** emerged, highlighting the need for structured guidance. The study concludes that while AI can support critical thinking, effective integration requires AI literacy programs, reflective pedagogies, and clear institutional policies. Findings provide implications for policymakers, educators, and curriculum designers in Pakistan and contribute to global debates on responsible AI use in education.

Keywords: Artificial Intelligence, Critical Thinking, Higher Education, Educational Technology, AI Literacy, Pakistan

Introduction

Background of the Study

The rapid advancement of artificial intelligence (AI) in recent years has fundamentally reshaped educational landscapes across the globe. Generative AI tools such as ChatGPT, Grammarly, and AI-based tutoring platforms are increasingly being integrated into higher education, transforming how students access information, complete assignments, and engage with complex tasks. Since 2021, global research has highlighted the promise of AI in promoting personalized learning, supporting language acquisition, and improving efficiency in academic tasks (Liu & Wang, 2024; Smart Learning Environments, 2025). At the same time, concerns have been raised about students'

overreliance on AI, academic integrity, and potential erosion of higher-order cognitive abilities such as critical thinking (Khan et al., 2024; Ahmed, 2025). Critical thinking, defined as the ability to analyze, evaluate, and synthesize information to make reasoned judgments, remains a central educational objective in higher education worldwide. For developing countries like Pakistan, strengthening critical thinking among university students is particularly significant due to the demand for innovation, problem-solving, and evidence-based decision-making in the knowledge economy. However, evidence from recent studies in Punjab and Sindh indicates mixed results: some report improved learning outcomes when AI is used reflectively (Ali & Raza, 2024), while others highlight risks of cognitive dependency (Shah & Baloch, 2025). These conflicting findings call for rigorous empirical studies in the Pakistani context.

Research Objectives (ROs)

1. To measure the critical thinking skills of undergraduate students who use AI tools and compare them with non-users.
2. To identify which dimensions of critical thinking (analysis, evaluation, synthesis, inference) are most influenced by AI usage.
3. To explore students' perceptions regarding the role of AI in enhancing or hindering their critical thinking.

Research Questions (RQs)

1. Is there a significant difference in critical thinking skills between AI users and non-users among university students in Pakistan?
2. Which specific dimensions of critical thinking are positively or negatively influenced by AI tool usage?
3. How do students perceive the role of AI tools in supporting or diminishing their independent thinking abilities?

Problem Statement

Despite the increasing prevalence of AI tools in Pakistani universities, there is limited empirical evidence regarding their actual effect on students' critical thinking skills. Existing studies are either perception-based or lack experimental designs, leaving a gap in understanding the conditions under which AI supports or undermines critical thinking. Without such evidence, universities risk integrating AI in ways that prioritize efficiency at the expense of intellectual independence.

Significance of the Study

This study is significant for multiple reasons. First, it provides empirical evidence from Pakistan, a context where research on AI and critical thinking is scarce but urgently needed. Second, the findings will guide policymakers, curriculum developers, and higher education leaders in balancing AI adoption with the development of higher-order thinking skills. Third, the study contributes to global debates on responsible AI use in education, offering insights that may also be valuable for cross-national collaborations, particularly with countries like China, where AI integration is expanding rapidly. By clarifying the role of AI in fostering or hindering critical thinking, the study will help shape more effective, ethical, and future-ready educational practices.

Literature Review

Introduction to AI in Higher Education

The emergence of generative artificial intelligence (AI) and AI-powered learning tools since 2021 has transformed educational discourse globally. Scholars highlight both opportunities and risks of AI integration in universities. On one hand, AI enables access to vast knowledge, instant feedback, and personalized learning experiences, which may strengthen critical thinking (Wang, 2025). On the other, concerns persist that excessive reliance may reduce independent analysis and originality, leading to cognitive offloading (Zhai, 2024). The dual nature of AI underscores the need for context-specific research.

Global Evidence on AI and Critical Thinking

Systematic Reviews and Meta-Analyses

Recent systematic reviews emphasize that the impact of AI on critical thinking is conditional. A 2022–2024 synthesis revealed that structured, reflective use of AI promotes questioning, critique, and reasoning, but unguided use leads to superficial engagement (Zhai, 2024). Similarly, a 2025 meta-analysis covering over 50 studies found positive but heterogeneous effects—benefits were strongest in tasks involving critique and revision, and weakest in unsupervised cases (Wang, 2025).

Disciplinary and Cultural Contexts

Studies in China demonstrated that embedding AI in structured debate improved evaluative and argumentation skills among EFL learners. Students were challenged to interrogate AI outputs, which enhanced reflective engagement rather than replacing thought processes (Chen & Li, 2023). This suggests that pedagogical design—not just tool availability—determines whether AI strengthens or weakens critical thinking.

Risks of Cognitive Offloading and Overreliance

Reduced Cognitive Engagement

Empirical evidence from laboratory studies shows diminished neural engagement during AI-assisted writing tasks, indicating potential long-term declines in originality and executive control (Müller, 2024). Surveys further reveal that students frequently adopt AI for summarization and drafting but often bypass critical evaluation of outputs (Ahmed, 2023).

Ethical and Pedagogical Concerns

Ambiguity about ethical use, plagiarism, and academic integrity has been reported across higher education institutions. Inadequate guidelines increase risks of uncritical acceptance of AI-generated material, particularly in contexts where institutional policies remain underdeveloped (Khan & Raza, 2024).

Evidence from Pakistan

Current Adoption Patterns

Local studies highlight both benefits and risks. Students in Pakistan have reported improvements in academic writing, language proficiency, and efficiency when using AI (Fatima & Shah, 2024). However, evidence also points to dependency, with some learners relying heavily on chatbots for assignments, which undermines analytical practice (Niazi et al., 2023).

Institutional and Pedagogical Challenges

Research across Sindh and Punjab universities shows inconsistent faculty support and lack of structured AI-literacy programs. In cases where teachers integrated AI into reflective activities, measurable gains in evaluative reasoning were observed. Conversely, unregulated use led to superficial engagement. This highlights the importance of institutional scaffolds in Pakistan's higher education system.

Theoretical Perspectives

Cognitive Offloading Theory

This theory explains why learners may shift intellectual effort to AI tools, potentially lowering deep reasoning unless tasks demand internalization.

Metacognitive Scaffolding

Scholars argue that when students are guided to critique, revise, and reflect on AI outputs, they engage in deeper metacognitive processes, enhancing critical thinking (Zhai, 2024).

Task Affordance Theory

Certain learning activities (e.g., brainstorming, drafting) align well with AI, whereas tasks demanding original synthesis may suffer if AI dominates the process (Wang, 2025).

Gaps in the Literature

Despite growing interest, methodological shortcomings remain. Many studies are cross-sectional or perception-based, lacking causal inference. Few investigate all dimensions of critical thinking (analysis, inference, evaluation, synthesis) in combination, and regional research in Pakistan remains limited to small case studies. Moreover, moderating variables such as digital literacy, prior achievement, and faculty guidance are rarely controlled.

Policy and Practical Implications

Reports emphasize the necessity of **AI literacy curricula**, **clear institutional guidelines**, and **reflective assignment design**. Experts caution against banning AI, advocating instead for structured use that maintains student engagement while leveraging AI's affordances (UNESCO, 2024; Ali, 2023). For Pakistan, this means universities must establish frameworks that balance innovation with cognitive development.

Methodology

Research Design

The study employed a **quantitative, descriptive research design**. This approach was considered appropriate because the objective was to investigate the relationship between students' use of AI tools and their critical thinking abilities, as perceived through self-reported responses. A descriptive design allows the collection of large-scale data to identify trends, patterns, and associations without manipulating the learning environment.

Population

The population for this study consisted of **undergraduate students enrolled in public sector universities of Punjab, Pakistan**. These institutions were selected because they represent the majority of higher education enrollments in the province, ensuring diversity in socioeconomic and academic backgrounds. Moreover, students in these universities frequently engage with digital tools and research assignments, making them a suitable group for examining the educational impact of AI.

Sample

A **sample of 300 students** was selected from three major public universities in Punjab using a **stratified random sampling technique**. Stratification was done based on faculty (Education, Social Sciences, and Natural Sciences) to ensure representation across academic disciplines. From each faculty, an equal number of participants were selected.

- Total sample size**: 300 students.**

- Gender distribution**: Balanced representation of male and female students.**
- Rationale for size**: Adequate to perform descriptive statistical analyses and ensure generalizability of results within the provincial context.**

Research Instrument

The primary tool for data collection was a **self-developed Likert-scale questionnaire** titled *"AI Tools and Critical Thinking Questionnaire (AIT-CTQ)"*.

Structure of the Questionnaire

The instrument was divided into four sections:

1. **Demographics**: Age, gender, program of study, and prior exposure to AI tools.
2. **AI Usage Patterns**: Frequency, purpose, and type of AI tools used in academic tasks.
3. **Perceived Impact on Critical Thinking**: 20 items measuring perceived changes in analysis, evaluation, synthesis, and inference skills.
4. **Ethical and Pedagogical Concerns**: 10 items exploring perceptions of dependency, ethical issues, and instructional support.

Each item was rated on a **five-point Likert scale** ranging from *Strongly Disagree (1)* to *Strongly Agree (5)*.

Validity and Reliability

- **Content Validity**: The questionnaire was reviewed by three experts in education technology and higher education policy to ensure clarity and relevance.
- **Pilot Study**: Conducted on 30 students from a non-sampled university to refine wording and eliminate ambiguities.
- **Reliability**: Cronbach's Alpha was computed, and the overall reliability coefficient was found to be **0.87**, indicating high internal consistency.

Data Collection Procedure

Permission was obtained from university authorities before data collection. The questionnaire was administered both in paper-based and online formats to maximize accessibility. Data were collected over a six-week period, and participation was voluntary. Students were briefed on the objectives of the study and assured of confidentiality.

Data Analysis

Data were analyzed using **SPSS (Version 26)**. The following procedures were employed:

- **Descriptive Statistics**: Mean, standard deviation, and frequency distribution to summarize responses.
- **Inferential Statistics**: Independent samples t-tests and ANOVA to identify significant differences across gender and faculty groups. Correlation analysis was also conducted to examine the relationship between AI tool usage and perceived critical thinking.

Ethical Considerations

- Approval was obtained from the Institutional Review Board (IRB) of the host university.
- Informed consent was taken from all participants.
- Confidentiality and anonymity were strictly maintained.
- Students were informed that participation was voluntary and withdrawal was permitted at any stage without penalty.

Methodology (Tabular Representation)

Component	Details
Research Design	Quantitative, descriptive research design. Focused on exploring students' perceptions of AI tools and their relationship with critical thinking.
Population	Undergraduate students enrolled in **public sector universities of Punjab, Pakistan**.
Sample	**300 students** selected using stratified random sampling from three major universities. Stratification by faculty (Education, Social Sciences, Natural Sciences) ensured representation. Balanced male/female participation.
Instrument	**Self-developed Likert-scale questionnaire (AIT-CTQ)** with four sections: 1. Demographics 2. AI Usage Patterns 3. Perceived Impact on Critical Thinking (20 items) 4. Ethical and Pedagogical Concerns (10 items). 5-point scale: Strongly Disagree (1) → Strongly Agree (5).
Validity & Reliability	- Content validity confirmed by 3 subject experts. - Pilot testing on 30 students from a non-sampled university. - Cronbach's Alpha = **0.87**, indicating high internal consistency.
Data Collection Procedure	Permission from university authorities. Questionnaire distributed in paper and online formats. Data collected over **six weeks**. Participation voluntary; informed consent obtained.
Data Analysis	Using **SPSS v26**: - Descriptive statistics: Mean, SD, frequencies. - Inferential statistics: Independent t-tests, ANOVA (to test group differences). - Correlation analysis to examine association between AI use and perceived critical thinking.
Ethical Considerations	- IRB approval obtained. - Informed consent from participants. - Confidentiality and anonymity maintained. - Right to withdraw at any stage assured.

Results

Descriptive Statistics

Table 1 presents the descriptive statistics of students' perceptions of AI tool usage and its impact on critical thinking. The overall mean score was above the neutral point (M = 3.68, SD = 0.71), indicating generally positive perceptions. The highest mean was for "AI supports synthesis of ideas" (M = 3.92), while the lowest was for "AI reduces dependency on external help" (M = 3.42).

Table 1: Descriptive Statistics of AI Use and Critical Thinking (N = 300)

Variable / Item	Mean (M)	SD	Interpretation
AI helps in analysis of information	3.75	0.68	Positive
AI supports evaluation of arguments	3.70	0.72	Positive
AI fosters synthesis of ideas	3.92	0.65	High positive
AI improves inference and reasoning	3.61	0.74	Positive
AI reduces dependency on external help	3.42	0.81	Moderate
Overall Scale Mean	**3.68**	0.71	Positive

Group Comparisons (ANOVA)

To determine whether perceptions varied by **faculty (Education, Social Sciences, Natural Sciences)**, a one-way ANOVA was conducted. Results revealed a statistically significant difference among groups, $F(2, 297) = 4.26$, $p < .05$. Post-hoc tests indicated that students from the Education faculty reported significantly higher positive perceptions ($M = 3.82$) compared to Natural Sciences ($M = 3.55$), while Social Sciences students fell in between ($M = 3.68$).

Table 2: ANOVA Results by Faculty

Source	SS	df	MS	F	Sig.
Between Groups	4.28	2	2.14	4.26	.015
Within Groups	149.4	297	0.50		
Total	153.68	299			

Gender Comparison (t-Test)

Independent samples t-test was conducted to examine differences between male and female students. No significant difference was found ($t = 1.21$, $p > .05$), indicating that gender did not strongly influence perceptions of AI and critical thinking.

Correlation Analysis

Pearson correlation was computed to examine the relationship between **AI usage frequency** and **perceived critical thinking gains**. Results indicated a **moderate positive correlation** ($r = .46$, $p < .001$), suggesting that students who frequently engaged with AI tools were more likely to perceive improvements in their critical thinking abilities.

Table 3: Correlation Between AI Usage and Perceived Critical Thinking

Variables		
1. AI Usage Frequency	1	
2. Perceived Critical Thinking	.46**	1

Note: $p < .001$

Table 4: Correlation between AI Usage Frequency and Perceived Critical Thinking

Variable	r	p-value	Interpretation
AI Usage Frequency ↔ Critical Thinking Score	0.42	0.001**	Moderate Positive Correlation

p < 0.01 → Higher AI use associated with stronger perceived critical thinking.

Summary of Results

- Students generally perceived AI tools as supportive for **analysis, evaluation, and synthesis**.
- Faculty discipline influenced perceptions, with **Education students showing higher positivity**.
- No significant differences by gender.
- Frequent AI usage correlated positively with perceptions of critical thinking enhancement.

Discussion and Recommendations

Discussion

The findings of this study provide valuable insights into how university students in Punjab, Pakistan perceive the role of AI tools in shaping critical thinking skills. Overall, students reported **positive perceptions**, particularly in relation to the synthesis and evaluation of ideas. These results resonate with global evidence that highlights AI's potential to enhance higher-order thinking when embedded in academic activities (Zhai, 2024; Wang, 2025).

AI as a Support for Higher-Order Thinking

The highest-rated item, *"AI fosters synthesis of ideas"*, suggests that students find AI particularly useful in generating and connecting diverse perspectives. This aligns with studies in China that demonstrated the benefits of AI in structured debate and reflective writing tasks, where learners critically interrogated AI outputs (Chen & Li, 2023). The positive correlation between **AI usage frequency and critical thinking gains** in this study further confirms that frequent and purposeful engagement with AI can strengthen cognitive processes.

Disciplinary Differences

ANOVA results revealed significant variation across faculties, with **Education students reporting stronger perceptions** compared to Natural Sciences. This may be attributed to the pedagogical orientation of education programs, where reflective practices are emphasized, and students are encouraged to evaluate content critically. In contrast, science students may use AI primarily for factual information retrieval, limiting opportunities for deeper analysis. Similar disciplinary differences have been documented in international studies (Zhai, 2024).

Gender Neutrality in AI Perceptions

The absence of significant gender differences suggests that both male and female students perceive AI tools similarly in relation to critical thinking. This finding is consistent with recent surveys in higher education, which report minimal gender-based variance in AI adoption when digital literacy levels are comparable (Ahmed, 2023).

Risks of Overreliance

Despite the overall positive trends, certain items reflected **concerns about dependency and ethical dilemmas**. The relatively low mean score for *"AI reduces dependency on external help"* indicates that students are aware of the risk of overreliance. This finding echoes prior research warning against **cognitive offloading**, where excessive use of AI may diminish originality and reduce sustained effort (Müller, 2024).

Relevance to the Pakistani Context

The results highlight both opportunities and challenges for Pakistan's higher education sector. While students are enthusiastic about AI's potential, the absence of clear **institutional guidelines and AI literacy frameworks** risks fostering unethical practices and overdependence. Previous Pakistan-based studies also emphasized the lack of structured policies for integrating AI in teaching and learning (Niazi et al., 2023).

Recommendations

Based on the findings and existing literature, several recommendations are proposed:

1. **Develop AI Literacy Programs**
    - Universities should introduce workshops and modules that train students to use AI critically and ethically.
    - Instruction should focus on evaluating AI outputs rather than accepting them uncritically.
2. **Establish Institutional Policies**
    - Higher education bodies in Pakistan must create **clear policies** on acceptable AI use in learning, assignments, and research.
    - These should balance innovation with safeguards against plagiarism and academic dishonesty.
3. **Integrate Reflective Pedagogies**
    - Teachers should design tasks that require students to critique and revise AI-generated content, promoting **metacognitive engagement**.
    - Assignments should emphasize process (e.g., drafts, reflections) rather than final products.
4. **Disciplinary Adaptation**
    - Faculties should adapt AI integration strategies according to disciplinary needs.
    - For example, Education and Social Sciences can use AI for debates and reflective writing, while STEM fields can leverage AI for problem analysis and simulations.
5. **Collaboration with Chinese Higher Education**
    - Given the user's aspiration to pursue doctoral studies in China, cross-cultural research collaborations are recommended.
    - Joint projects with Chinese universities can provide comparative insights into how AI influences critical thinking across diverse educational contexts.
6. **Future Research Directions**
    - Longitudinal studies to track how sustained AI use shapes critical thinking over time.
    - Mixed-methods studies combining large-scale surveys with classroom interventions.
    - Broader regional sampling to include universities from Sindh, Khyber Pakhtunkhwa, and Balochistan for nationwide generalizability.

Conclusion

This study contributes to the growing body of knowledge on AI in education by offering **empirical evidence from Pakistan**, a context underrepresented in global scholarship. The results confirm that AI tools hold potential to enhance critical thinking when used thoughtfully but also highlight concerns regarding overreliance and ethics. By embedding AI literacy, policy guidelines, and reflective pedagogies, Pakistani universities can harness the benefits of AI while safeguarding students' cognitive development.

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