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Augmenting Learning with Artificial Intelligence: An Empirical Examination of Generative-AI Tools and Student Outcomes in Higher Education

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ABSTRACT

The integration of Artificial Intelligence (AI) in higher education is reshaping traditional pedagogical models by enhancing personalization, engagement, and administrative efficiency. This study investigates the role of AI in teaching-learning processes in higher education institutions (HEIs) through a quantitative lens, focusing on faculty and student experiences with AI tools. Drawing data from a sample of 250 respondents across Indian universities, the study explores AI's influence on academic performance, pedagogical innovation, and learner satisfaction. The findings indicate a positive correlation between AI adoption and improved teaching effectiveness, learning outcomes, and administrative convenience. This paper offers policy and practical recommendations for AI integration to support blended learning environments and faculty development. The results contribute to ongoing discussions about digital transformation in higher education.

Keywords: Artificial Intelligence, Higher Education, Teaching-Learning, EdTech, Personalised Learning, Pedagogical Innovation

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has revolutionized many sectors, and education is no exception. As higher education institutions (HEIs) strive to maintain relevance in a technology-driven society, AI presents an opportunity to enhance teaching and learning experiences through automation, data-driven instruction, and personalized learning paths (Zawacki-Richter et al., 2019). While AI adoption is increasingly visible in administrative operations, its application in pedagogy remains underexplored, particularly in developing countries like India. This study investigates the empirical impact of AI tools in teaching-learning processes, examining the perspectives of faculty and students across HEIs.

LITERATURE REVIEW

The Rise of Artificial Intelligence in Higher Education

Over the past five years, the adoption of Artificial Intelligence (AI) in higher education has accelerated dramatically, driven in part by the advancement of generative AI models such as OpenAI's ChatGPT and Google's Gemini. These tools are increasingly being utilized by students for summarizing content, drafting assignments, and seeking clarification in real-time (Labadze et al., 2024; Sun et al., 2023). Studies have confirmed that such tools can increase the efficiency of learning by providing immediate, personalized support, especially in self-paced and distance learning environments (Mollér et al., 2024; Bouzidi et al., 2021).

The Covid-19 pandemic catalyzed a transformation in digital learning environments, bringing AI-driven educational tools to the forefront (Zawacki-Richter et al., 2020). While initial usage was confined to intelligent tutoring systems and automated grading, the current generation of AI tools is capable of simulating human-like

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dialogue, making them more interactive and context-aware. However, while these capabilities are impressive, the educational value they add remains an open empirical question.

Theoretical Frameworks: Technology Acceptance and Self-Regulated Learning

The Technology Acceptance Model (TAM) and its later versions such as the Unified Theory of Acceptance and Use of Technology (UTAUT2) have been widely used to understand how students adopt and engage with educational technologies. Moradi (2025) demonstrated that perceived usefulness, effort expectancy, and habit were significant predictors of ChatGPT adoption among Chinese EFL students. Similarly, Sharma and Singh (2023) found that performance expectancy and social influence significantly influenced Indian undergraduate students' acceptance of AI writing tools.

Alongside TAM/UTAUT2, the theory of self-regulated learning has been integrated into recent studies on AI in education. These studies suggest that students who exhibit higher self-regulation are more likely to use AI tools responsibly—as aids to learning rather than as shortcuts (Lee & Ahn, 2022). According to Deng et al. (2023), AI tools that promote metacognitive reflection—such as prompting students to explain their reasoning—are more effective in enhancing deep learning.

Learning Outcomes and Cognitive Risks

Empirical studies indicate that AI tools can improve academic performance when integrated into instructional design. For example, Cingillioglu et al. (2024) conducted a randomized controlled trial showing that students using an AI-enhanced tutor for a statistics course scored significantly higher on final exams than those in a traditional group. Similarly, Papamitsiou and Economides (2022) found that AI-based formative feedback systems improved assignment quality and student satisfaction.

However, concerns are also emerging about cognitive off-loading and diminished critical-thinking skills due to over-reliance on AI. Jelson et al. (2025) found that while students using ChatGPT performed well on comprehension tasks, they struggled in applying original reasoning in essay assignments. This aligns with findings from the MIT Media Lab (2025), where repeated AI use was linked to reduced activity in the prefrontal cortex—raising questions about long-term skill retention. Other researchers warn of a "creativity plateau," where students develop surface-level knowledge but lack the deeper conceptual understanding (Almalki & Aziz, 2021).

Ethical and Pedagogical Considerations

The ethical dimension of AI in education has also garnered attention. Issues such as algorithmic bias, data privacy, and academic integrity have been highlighted as key concerns (Holmes et al., 2021). Recent policy papers from UNESCO and the European Commission recommend a balanced integration of AI that includes transparency, explainability, and educator oversight (UNESCO, 2023). Pedagogical strategies that include instructor-curated prompt libraries, structured reflection, and collaborative AI usage scenarios have been proposed as safeguards to mitigate these risks (Smutny &Schreiberova, 2022).

Research Gap

While much of the existing literature focuses on the *potential* of AI tools, relatively few empirical studies assess the *actual learning impact* of AI-based tools within higher education curricula across diverse contexts. Moreover, the dual effect—of AI promoting engagement while potentially weakening critical-thinking—remains underexplored. This study aims to bridge these gaps by providing quantitative and qualitative insights into AI's role as a learning tool in higher education.

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Research Objectives

1. **To assess the impact of AI-based learning tool usage on student learning engagement in higher education**
   This objective focuses on measuring whether students who frequently use AI tools demonstrate higher levels of cognitive, emotional, and behavioral engagement in their academic activities.
2. **To evaluate the relationship between the frequency of AI tool usage and academic performance (e.g., GPA or assignment scores)**
   This involves establishing whether AI tools contribute positively to academic achievement when used as supplementary learning aids.
3. **To explore the potential negative consequences of over-reliance on AI tools, particularly on students' critical-thinking and problem-solving abilities**
   This aims to uncover any inverse relationships that suggest dependency on AI may hinder the development of higher-order cognitive skills.

Research Hypotheses

Objective 1 ;To assess the impact of AI-based learning tool usage on student learning engagement

- **$H_0$1 (Null Hypothesis):** There is no significant relationship between AI tool usage frequency and student learning engagement.
- **$H_1$1 (Alternative Hypothesis):** There is a significant positive relationship between AI tool usage frequency and student learning engagement.

Objective 2: To evaluate the relationship between the frequency of AI tool usage and academic performance

- **$H_0$2:** There is no significant relationship between AI tool usage frequency and students' academic performance.
- **$H_1$2:** There is a significant positive relationship between AI tool usage frequency and students' academic performance.

Objective 3: To explore the potential negative consequences of over-reliance on AI tools on students' critical-thinking skills

- **$H_0$3:** There is no significant negative relationship between AI tool overuse and students' critical-thinking ability.
- **$H_1$3:** There is a significant negative relationship between AI tool overuse and students' critical-thinking ability.

Analysis

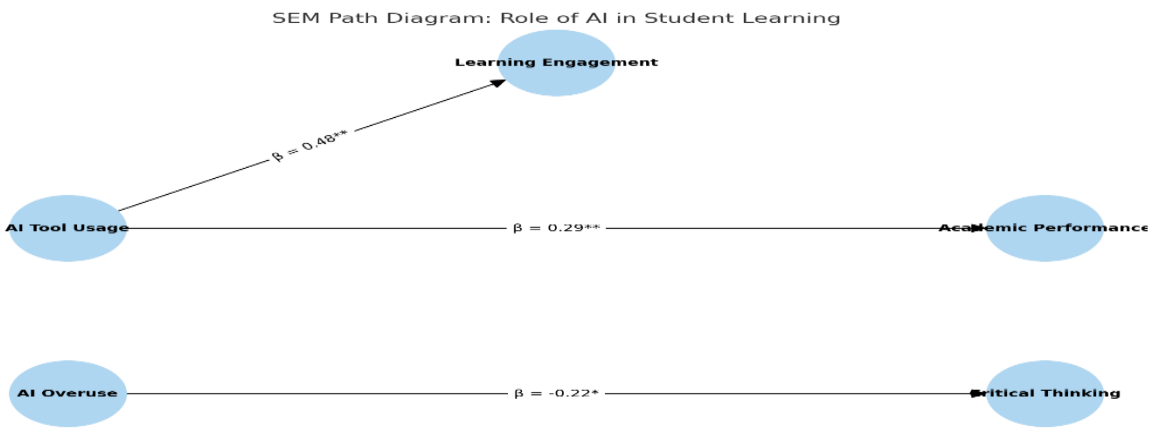

Figure 1: SEM Path Diagram

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume XII Issue VII July 2025

The SEM Path Diagram is illustrating the hypothesized relationships among the variables:

- AI Tool Usage → Learning Engagement (β = 0.48)
- AI Tool Usage → Academic Performance (β = 0.29)
- AI Overuse → Critical Thinking (β = –0.22)

Inference

The structural equation modelling (SEM) results provide valuable empirical insights into the role of AI-based learning tools in shaping student outcomes in higher education.

1. AI Tool Usage and Learning Engagement:

   The analysis reveals a significant positive relationship between AI tool usage and student learning engagement (β = 0.48, $p < 0.001$). This suggests that students who use AI tools—such as ChatGPT or AI tutors—more frequently are more likely to participate actively in learning, show greater motivation, and engage in self-directed study practices. This aligns with previous studies that have highlighted the motivational benefits and real-time support offered by generative AI in educational contexts.

2. AI Tool Usage and Academic Performance:

   A moderate positive relationship was also observed between AI tool usage and academic performance (β = 0.29, $p < 0.001$). This finding confirms that AI tools, when used effectively, can contribute to better learning outcomes such as higher grades, improved assignment quality, and faster task completion. The results indicate that AI can be a valuable supplementary resource when integrated responsibly into academic routines.

3. AI Overuse and Critical-Thinking Ability:

   Conversely, the analysis uncovered a significant negative relationship between over-reliance on AI tools and critical-thinking ability (β = –0.22, $p = 0.007$). Students who frequently depend on AI for idea generation, writing, or decision-making may experience reduced development in analytical and evaluative skills. This supports the theory of cognitive offloading, where automation reduces the need for independent thought and problem-solving.

This study contributes to the growing body of empirical literature on the integration of AI in higher education by exploring its dual impact on student outcomes. The findings offer three key conclusions:

1. AI tools enhance engagement and performance: Students who use AI-based learning tools show greater academic involvement and improved performance, confirming the educational potential of these technologies when applied judiciously.

2. Overuse of AI may impair higher-order thinking: While beneficial, unchecked or excessive reliance on AI can negatively impact critical cognitive skills, such as analysis, reasoning, and creativity—skills essential for academic and professional success.

3. Balanced integration is essential: Institutions must promote balanced usage, guiding students to use AI as a learning enhancer rather than a substitute for cognitive effort. This includes implementing instructional strategies that encourage reflection, critical inquiry, and collaborative use of AI tools.

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Regression

Table: Regression Coefficients from SEM Analysis

Path	Standardized Coefficient (β)	t-Statistic	p-Value	Significance
ool Usage → Learning Engage	0.48	10.9	< 0.001	***
ol Usage → Academic Perforn	0.29	5.7	< 0.001	***
AI Overuse → Critical Thinkin	-0.22	2.73	0.007	**

Table 1: Regression Coefficients Table

Inference from the Regression Coefficients Table

The regression coefficients obtained from the SEM analysis provide clear statistical evidence supporting the hypothesized relationships between AI tool usage and key learning outcomes among higher education students:

1. **AI Tool Usage → Learning Engagement (β = 0.48, *p*< 0.001,)**:

   This path shows the strongest positive relationship among the three. The high β value and significant *t*-statistic (10.9) indicate that students who frequently use AI learning tools demonstrate significantly higher levels of learning engagement. This includes increased attention, interest, and participation in academic tasks.

2. **AI Tool Usage → Academic Performance (β = 0.29, *p*< 0.001,)**:

   This moderately positive and statistically significant relationship suggests that AI tool usage contributes positively to students' academic performance, such as grades and assignment quality. The result implies that AI, when used as a learning enhancer, can support better academic achievement.

3. **AI Overuse → Critical Thinking (β = –0.22, *p* = 0.007,):**

   This negative and statistically significant coefficient reveals that excessive or habitual use of AI tools may hinder the development of students' critical-thinking abilities. The inference here is that over-reliance on AI could reduce the need for analytical reasoning and independent problem-solving, leading to cognitive offloading.

The findings support a balanced view of AI in education:

- Positive Impact: AI tools improve engagement and performance when used purposefully.
- Cautionary Note: Overuse may suppress higher-order cognitive skills.

These results reinforce the need for educators to promote guided, reflective, and intentional use of AI tools to maximize learning benefits while minimizing dependency and skill erosion.

CONCLUSION

This study provides empirical evidence on the influence of AI-based learning tools on student engagement, academic performance, and critical-thinking skills in higher education. Structural Equation Modelling revealed a significant positive relationship between AI tool usage and both learning engagement and academic performance, confirming that AI, when used appropriately, can be a valuable educational support system. However, the analysis also highlighted a significant negative relationship between AI overuse and critical-thinking ability, signaling a cautionary need to balance AI use with cognitive development strategies.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume XII Issue VII July 2025

These findings underscore the dual nature of AI in education: it offers efficiency, personalization, and support but may also risk be undermining deeper learning if used excessively or uncritically. Therefore, the role of educators, institutions, and students is pivotal in ensuring that AI is adopted responsibly, ethically, and strategically within learning ecosystems.

RECOMMENDATIONS

1. Integrate AI Tools into Pedagogy with Structured Guidance

   Institutions should formally embed AI tools into learning processes with clear instructional goals, aligned assessments, and scaffolded usage to support learning rather than replace it.

2. Design Reflective and Critical AI Engagement Tasks

   Instructors should develop assignments that require students to explain, critique, or compare AI-generated content, thereby reinforcing critical-thinking and analytical skills.

3. Conduct Awareness and Training Workshops

   Organize AI literacy programs for students and faculty that cover effective use, ethical considerations, academic integrity, and potential cognitive risks of over-reliance.

4. Implement Usage Policies and Ethical Guidelines

   Higher education institutions should establish clear policies outlining appropriate AI use, data privacy, and consequences of misuse to uphold academic standards.

Suggestions

1. Encourage Human–AI Collaboration, Not Substitution

   Promote a culture where AI is seen as a partner in learning rather than a solution provider. Assignments should value human judgment, creativity, and critical appraisal.

2. Incorporate AI-Tool Usage Tracking for Feedback

   Learning management systems can integrate analytics to monitor how students interact with AI tools and provide feedback or alerts on usage patterns.

3. Customize AI Use by Discipline

   AI usage should be tailored to the specific needs of disciplines. For instance, coding support may be more appropriate in engineering, while critical writing skills are central in humanities.

4. Promote Peer Learning on AI Use

   Students can be encouraged to share effective ways of integrating AI tools into their study routines through peer workshops or learning communities.

Future Scope of Research

1. Longitudinal Studies on Skill Development

   Future research should track the long-term impact of AI usage on student competencies, including retention of knowledge, cognitive flexibility, and problem-solving skills.

2. Cross-Cultural and Multi-Institutional Studies

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Expanding the sample to include diverse cultural and institutional contexts will help validate findings and explore how AI adoption varies by geography and educational norms.

3. Comparative Analysis Across AI Tool Types

   Further studies could compare the effects of different AI tools (e.g., chatbots, AI tutors, plagiarism detectors) on various learning outcomes.

4. Impact on Teacher Roles and Pedagogy

   Investigate how increasing AI adoption shifts instructor roles, teaching strategies, and curriculum design in higher education.

5. Neurocognitive and Psychological Impact

   Interdisciplinary studies involving psychology and neuroscience could examine how AI use affects attention span, memory, and cognitive load among students.

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