

Pedagogical Innovation through Generative AI: Benefits, Challenges, and Responsible Use in Higher Education

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Abstract: The rapid integration of Generative Artificial Intelligence (GAI) into higher education has transformed how students engage in learning and educational activities, including personalized learning, creativity, and knowledge production. This study aims to explore the adoption patterns, perceived benefits, and challenges of using GAI tools such as ChatGPT, DeepSeek, and Google Gemini in higher education. A quantitative survey was conducted with 102 students from higher education institutions across various disciplines and degree levels. Findings revealed that 77.5% of participants reported using GAI daily, master's students reported the highest benefit perception scores, while ethical and accuracy concerns were identified as the most pressing challenges; PhD students adopted a more critical stance. Findings further suggest that GAI has a positive influence on academic engagement and creativity; however, concerns about the ethical implications, responsible use, and originality remain critical challenges. This study, by highlighting both opportunities and challenges, provides actionable insights for teachers, learners, policymakers, and technology developers. It emphasizes the need for artificial intelligence AI literacy and responsible integration to ensure that GAI fosters sustainable and meaningful pedagogical innovation in higher education.

Keywords: Generative AI, Academic Engagement, Pedagogical Innovations, Digital Learning Outcomes, AI Ethics

1. Introduction

GAI has rapidly emerged as a transformative technology development across multiple sectors, including education (Younas et al., 2025; Bragg et al., 2021). In an academic context, students and professionals from various fields are utilizing GAI tools to tackle complex tasks effectively, such as information synthesis, academic writing, and problem-solving, often achieving substantial time-efficiency gains. So, the number of students who are integrating these tools into their educational activities has been accelerated markedly, as GAI tools are perceived to facilitate skill development through adaptive and personalized support mechanisms and are crucial for students to learn new skills in a unique and efficient manner (Mubarak & Selimin, 2023; Maqbool et al., 2024; Alghazo et al., 2025).

Recent studies by Elanwar (2025), Lang et al. (2025), and Mittal et al. (2024) revealed that GAI, including ChatGPT, Large Language Models (LLMs), and DALL-E, enhances students' learning and facilitates the creation of automated content while developing their creative problem-solving capabilities. Henceforth, to develop critical thinking skills among students, educational institutions are increasingly utilizing these tools on a broader scale, according to Luckin et al. (2022). Nevertheless, current research lacks an understanding of how generative AI affects students at the university level; this powerful technology may, however, enhance engagement and academic outcomes (Shamim et al., 2026). Thus, the primary objective of this research paper is to examine the impact of GAI on higher education, specifically in terms of academic management, creativity, and self-reported learning gains, as well as the associated challenges and ethical concerns.

This current study aimed to fill these gaps and provide a remarkable, empirically supported insight into the impact of Generative Artificial Intelligence tools on shaping students' academic engagement, creativity, and self-reported learning gains at the university level in Pakistan. In this research, we studied the pedagogical impacts of GAI at the university level, whereas the existing literature has examined its impact at a general level. By analyzing adoption patterns, perceived benefits, and challenges, this research will not only advance theoretical understanding but also yield practical implications for educators, policymakers, and technology developers. The findings demonstrated that recurrent use of generative AI correlates positively with perceived academic benefits, highlighting the importance of AI literacy and structured integration strategies. This highlights the transformative role of generative AI in enhancing learning efficiency, while also emphasizing the ethical and accuracy challenges that must be addressed for its sustainable adoption.

1.1 Research Objectives

- To quantify and characterize the adoption patterns of generative AI tools among university students across disciplines, degree levels, and institution types.
- To evaluate the perceived academic benefits of generative AI tools on learning outcomes.
- To identify and categorize the primary challenges (technical integration, accuracy concerns, ethical implications) associated with generative AI adoption in academic contexts.

1.2 Research Questions

- What are the patterns of GAI adoption among Pakistani university students?
- How does GAI usage influence academic engagement, creativity, and learning outcomes?
- What challenges are associated with GAI adoption in higher education?

2. Literature Review

In recent years, the inclusion of generative Artificial Intelligence in education, particularly in higher education, has dramatically increased interest among educators, researchers, students, and policymakers. This literature review synthesizes findings from recent studies published in renowned journals, such as those by Springer, to explore the impact of generative AI on academic engagement, creativity, and self-reported learning gains among university students. The review is structured around three key themes: (1) the role of generative AI in enhancing academic engagement, (2) its influence on fostering creativity, (3) its effects on self-reported learning gains, challenges while using AI tools, and (4) ethical considerations for university students. In the following subsections, we will highlight recent literature on these targeted research areas.

Recent studies (Mohamed et al., 2025; Owoseni et al., 2024; Sharma et al., 2025) suggest that generative AI tools, such as ChatGPT and other large language models, can significantly enhance student engagement by providing personalized learning experiences. For instance, Yu and Yao (2024) found that AI-driven platforms can adapt to individual learning styles, offering tailored feedback and resources that keep students motivated and engaged. Similarly, studies by Liu et al. (2025) and Song et al. (2025) found that generative AI can facilitate interactive learning environments, enabling students to participate more actively in discussions and problem-solving. However, concerns have been raised about the potential for over-reliance on AI tools, which may lead to reduced critical thinking and self-directed learning. As noted by George et al. (2024), while AI can enhance engagement, it is crucial to balance its use with traditional pedagogical methods to ensure students remain intellectually challenged.

Students at the university level are involved in technology-related academic activities to enhance their engagement, and GAI is playing a vital role in these activities. For instance, the research by Khan and Ullah (2024) and Meng et al. (2025) found that ChatGPT-supported classrooms in higher education significantly improved participation rates and reduced academic disengagement. Similarly, Du (2025), Imran and Almusharraf (2023), and Jabeen (2023) reported that AI-driven personalized tutoring systems enhanced time-on-task behaviors and improved intrinsic motivation among undergraduate learners. However, researchers caution that constant reliance on AI may lead to “engagement inflation,” in which students appear engaged but demonstrate shallow processing of content (Klingbeil et al., 2024). These findings align with the argument that AI should be integrated as a supplementary tool rather than a replacement for critical human-led instruction.

According to Feng et al. (2025), AI-based writing assistants improved argumentation quality and coherence in undergraduate essays, while Srivastava and Agarwal (2024) demonstrated improved retention rates in STEM subjects through multimodal AI-generated simulations. Nevertheless, differential outcomes have been reported across disciplines; for instance, humanities students often question AI’s interpretative validity compared to STEM learners. After careful analysis of these studies, we conclude that ethical issues, such as bias in AI outputs and data privacy risks, remain pressing challenges that can influence both the reliability and fairness of self-reported learning gains when relying entirely on GAI technologies during educational activities.

Although past studies have examined AI in education broadly, few focus specifically on GAI’s role in enhancing engagement, creativity, and measurable self-reported learning gains among university students in developing nations. Existing studies often focus on the broader applications of AI or its ethical implications, leaving the pedagogical and psychological impacts of generative AI underexplored. This study addresses this

gap by providing empirical evidence on how generative AI tools influence university students' academic experiences, offering a foundation for future research and practice in this emerging field. This research addresses this gap by providing empirical evidence from Pakistan, thereby contributing to both the local and global discourse on the integration of educational AI. The literature reviewed underscores the transformative potential of generative AI in higher education, particularly in enhancing academic engagement, fostering creativity, and improving learning outcomes. However, it also highlights the need for a balanced approach that integrates AI tools with traditional teaching methods while addressing ethical and pedagogical challenges.

3. Theoretical Framework and Methodology

For this study, we applied an integrated conceptual framework combining the Technology Acceptance Model (TAM) (Davis, 1989) and the Self-Determined Learning (Heutagogy) (Blaschke, 2012) framework. TAM posits that perceived usefulness and perceived ease of use are primary determinants of technology adoption. To measure the impact of GAI, we conceptualize self-rated proficiency as a substitute for ease of use and 'Perceived Benefits' as a measure of usefulness. Therefore, a quantitative, cross-sectional survey design was employed to enable statistical examination of patterns, correlations, and group differences in GAI usage and perceptions. For data analysis and visualization, we used Python libraries such as Matplotlib, NumPy, and Pandas in Google Colab.

This study investigates the impact of generative artificial intelligence on university-level education, with a specific focus on students' academic engagement, creativity, and learning outcomes. A stratified sampling method ensures representation across disciplines and degree levels. We employed a structured questionnaire, developed through a rigorous process using Microsoft Forms, to collect data from participants. The initial item pool was generated based on a comprehensive literature review of constructs related to technology adoption (Lai et al., 2022; Lai, 2017), academic engagement (Alrashidi et al., 2016; Perkmann et al., 2021), and creativity (Egan et al., 2017). The questionnaire was then reviewed by a panel of three experts in educational technology and psychometrics to establish content and face validity. The questionnaire was distributed digitally to ensure accessibility and broad participation. The study aims to provide empirical insights into how generative AI technologies are influencing higher education settings and to identify potential benefits and challenges associated with their integration into academic practices. Descriptive statistics, Spearman correlations, with Tukey post-hoc tests, and confirmatory factor analysis were performed using SPSS v28 and AMOS v26. Significance level was set at $\alpha = 0.05$.

4. Findings and Discussion

This section presents the results on the frequency and purpose of GAI tool use in higher education. Figure 1 shows a word cloud visualization of the distribution of academic fields reported by participants.



Figure 1: Major Field of Studies of Participants

The following Figure 2 illustrates the distribution of generative AI tool utilization frequency among 102 participants. The data reveals a predominance of daily usage, reported by 79 individuals, corresponding to 77.5% of the sample. Weekly use was reported by 16 participants (15.7%), while monthly use was reported by 5 participants (4.9%). Infrequent exertion patterns, including yearly use and non-use, were minimal, each reported by only 1 participant (1.0%). The clear concentration on the "Daily" category indicates greater integration of generative AI tools into participants' routines.

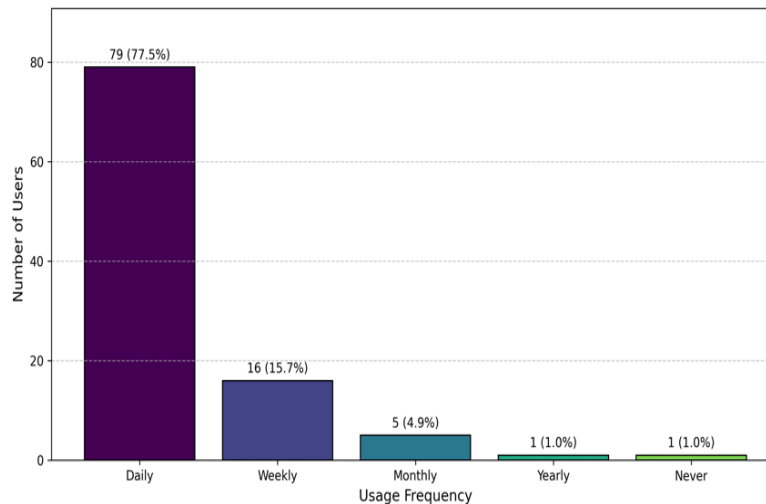


Figure 2: Usage Frequency Distribution of GAI Tools

From an interpretative standpoint, the prevalence of daily practice implies that generative AI tools have likely become essential operational aids for most users in this cohort. Such patterns could be driven by academic, professional, or personal productivity needs, reflecting both the perceived utility and accessibility of these technologies. The minimal representation of infrequent or non-users suggests that barriers to adoption in this population are either low or outweighed by perceived benefits, warranting further exploration of the specific drivers of sustained high-frequency use.

4.1 Influence of GAI on Academic Engagement, Creativity, and Self-reported Learning Gains

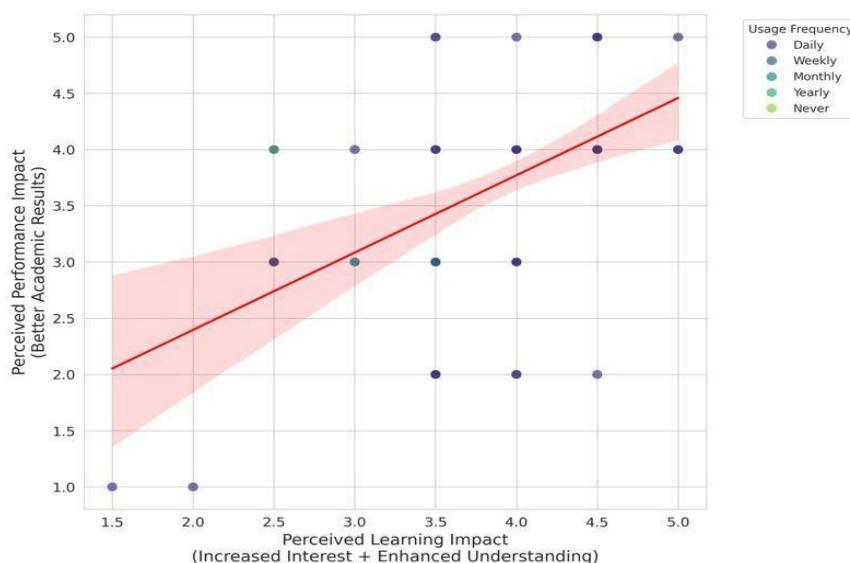


Figure 3: Relationship between perceived learning impact and perceived performance impact, with regression line (95% CI) indicating a weak but positive association across different usage frequencies.

Figure 3 displays a scatter plot with an overlaid linear regression line to visually explore the relationship between Perceived Learning Impact (increased interest and enhanced understanding) and Perceived Performance Impact (better academic results), categorized by GAI usage frequency. Visually, the regression line indicates a potential positive trend, suggesting that higher self-reported learning impacts may align with stronger perceived performance outcomes. The shaded region represents the 95% confidence interval, which appears narrower at higher response tiers (between 4.0 and 5.0). However, it is important to note that these observations are purely descriptive; no formal statistical testing (such as correlation coefficients or significance tests) was performed to confirm the strength, direction, or statistical significance of this association. Similarly, descriptive clustering shows that data points in the upper-right quadrant are predominantly associated with self-reported Daily users, while lower-impact scores appear more scattered among Weekly or Monthly users. While this descriptive pattern suggests a possible link between usage

frequency and perceived utility, these differences are not validated by formal comparative or inferential analyses. Consequently, any apparent variations between usage-frequency groups represent exploratory observations rather than definitive statistical conclusions and must be interpreted with caution.

4.2 Challenges Associated with GAI Adoption

Figure 4 highlights a violin plot visualizing the distribution of concern levels (measured on a Likert scale from 1 to 5) across three primary categories of AI-related challenges: Integration, Accuracy, and Ethical considerations. This type of plot integrates the features of a boxplot with a kernel density estimate, offering both summary statistics and the distribution shape for each challenge type. The horizontal axis categorizes the challenge type, while the vertical axis quantifies the level of concern.

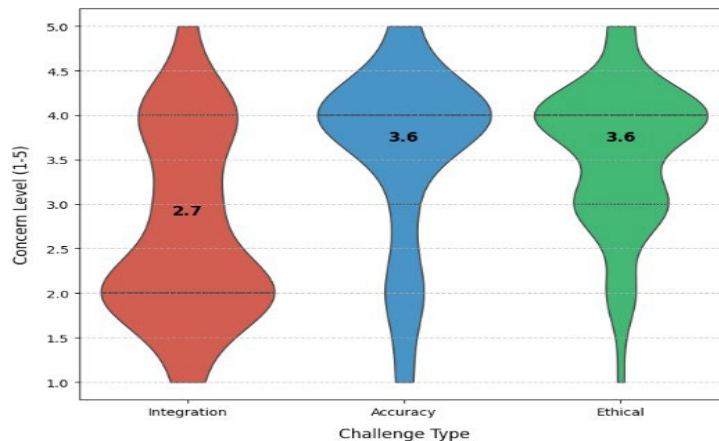


Figure 4: Perceived Challenges in AI adoption

Superimposed on each violin is a bold numerical label denoting the mean concern level for that category. Specifically, integration registers a lower mean concern of 2.7, whereas both Accuracy and Ethical challenges exhibit elevated concern levels of 3.6, suggesting heightened awareness or uncertainty in those domains. The differences in central tendency indicate that respondents are relatively less apprehensive about Integration issues, possibly due to increased familiarity or perceived manageability. At the same time, concerns about Accuracy and Ethics remain pronounced, likely reflecting persistent technical limitations and unresolved normative questions.

The findings of this research paper indicate that GAI is deeply embedded in students' academic activities, with periodic use far exceeding occasional use. Interestingly, master's students reported higher perceived benefits than both undergraduates and PhD candidates, perhaps reflecting optimal alignment between academic workload and AI support. Ethical and accuracy concerns remain key barriers to uninhibited adoption, a significant concern in past research (Chan & Tsi, 2024; Afzaal et al., 2020). Contrary to stronger claims in earlier drafts, the association between self-rated proficiency and self-reported academic improvement was statistically significant but weak (Spearman's $\rho = 0.09$, $p < .001$). This indicates that while higher proficiency is associated with slightly greater perceived academic improvement, proficiency alone explains very little variance in perceived outcomes.

This research work demonstrates its obviousness by highlighting perceptual differences at various academic levels within the university in Pakistan. The results of this study show that postgraduate students reported the highest perceived advantages, as they primarily used GAI tools for their research work, to complete assignments, and various research activities. In contrast, undergraduates benefited less, possibly due to their limited academic maturity, while PhD students expressed greater scepticism, reflecting a critical stance on AI's limitations.

Students reported that some responses were not accurate. Similarly, Weekes and Eskridge (2022) noted that AI can simultaneously act as a productivity enhancer and a cognitive risk. Ethical concerns remain salient, with students expressing unease about plagiarism, academic honesty, and bias in AI outputs. These issues highlight the urgency of implementing AI literacy programs that prioritise responsible use, critical appraisal of AI-generated content, and adherence to academic integrity standards. In Pakistan, where regulatory frameworks for GAI in higher education are still in the developing phase, these interventions would be critical for the smooth integration of GAI at the university level.

The findings further highlight intradisciplinary differences, as STEM students reported higher benefits than those in the humanities. This trend supports the findings of Yan et al. (2025), who found significant applicability of AI in technical and quantitative domains. Without discipline-specific frameworks, there is a risk of deepening existing educational disparities, particularly in resource-constrained contexts where institutional and socioeconomic barriers already shape access to digital tools (Munir et al., 2025). Universities should therefore adopt tailored strategies to ensure equitable integration across disciplines, recognizing the varying pedagogical needs of STEM and humanities learners.

Finally, the findings would advance the discourse on generative AI by reinforcing its pedagogical value while critically addressing its inherent limitations. AI tools can foster engagement, creativity, and efficiency. However, their transformative potential depends on balanced integration with traditional teaching, the cultivation of higher-order thinking skills, and the establishment of robust ethical safeguards. Also, longitudinal research is necessary to assess the enduring effects of AI adoption on knowledge retention, independent problem-solving, and critical reasoning. By situating the Pakistani selected universities case within the global discourse, this study may underscore the imperative for evidence-based policies and context-sensitive interventions that maximize the benefits of generative AI while safeguarding educational equity and intellectual integrity.

5. Conclusion

This study provides preliminary empirical observations regarding the integration of GAI tools among the selected Pakistani university students. Results revealed that 77.5% of participants use GAI regularly, with usage frequency and self-rated proficiency correlating with perceived benefits. Master's students disclosed the highest benefit perception scores, while ethical and accurate concerns were pinpointed as the most pressing challenges. The determinations further highlighted that, within this exploratory sample, GAI use is weakly associated with self-reported engagement and creativity, while also underscoring the importance of addressing ethical implications and ensuring responsible use. This preliminary analysis also offers insightful suggestions and recommendations for educators, policymakers, and learners, paving the way for future researchers to investigate GAI at a broader level and explore its impact in higher education. It further concludes that the higher prevalence of day-to-day GAI utilization and the tools that support it play a fundamental role as essential academic aids. At the same time, the correlation between proficiency and perceived benefits suggests that targeted AI literacy programs could amplify their educational value. Master's students' higher benefit perception points to a stage in academic progression where GAI tools optimally support research, writing, and problem-solving demands. Future research should explore longitudinal effects and the role of educators in mediating AI-driven learning experiences to maximize benefits for students.

6. Recommendations

This study proposes pivotal recommendations for educators, policymakers, and researchers. For educational practice, there is a need to develop and integrate mandatory AI literacy modules into the university curriculum to address the identified challenges and ethical considerations, along with prompt engineering, to save academic integrity and bias. Current analysis also advises policymakers to define acceptable applications of GAI that minimize plagiarism concerns during the evaluation of students' assignments, etc. Finally, this work would pave the way for future researchers, suggesting that to track the long-term impacts of GAI, longitudinal studies with mixed-methods approaches are needed, combining large-scale surveys and in-depth interviews.

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Conflict Statement

The authors declare no conflict of interest.

AI Declaration

We used Grammarly Premium for proofreading and language improvement in this study.

Ethical Declaration

During this study, all ethical principles were strictly followed; no human or animal cells or personal data were collected or used.

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