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Generative Artificial Intelligence and Cognitive Engagement: Redefining Learning Experiences in Universities

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ABSTRACT

The rapid advancement of Generative Artificial Intelligence (GenAI) has transformed higher education by enhancing teaching practices, cognitive engagement, and students' learning experiences. This paper examines the relationship of Generative Artificial Intelligence with cognitive engagement and learning experiences among students enrolled in selected public and private universities in Punjab and Sindh, Pakistan. The study employs a quantitative cross-sectional research design. Data were collected using a structured questionnaire on a sample of 433 students belonging to both public and private sector universities in Punjab and Sindh. The sampled universities are the University of the Punjab, Bahauddin Zakariya University, Islamia University of Bahawalpur, Government College University Faisalabad, University of Education Lahore, University of Sindh Jamshoro, Mehran University of Engineering and Technology, and the University of Karachi. The study utilized a non-probability convenience sampling. Data were collected online using Google Forms. The rest of the sample were screened in Microsoft Excel and analyzed in SPSS. Descriptive statistics along with, Pearson correlation, multiple linear regression, Independent Samples t-test, and One-Way ANOVA were used to meet the objectives of the study. The results demonstrated significant positive associations between Generative Artificial Intelligence, cognitive engagement, and learning experiences among the surveyed students, while statistically significant differences were also observed across selected demographic groups. The observed associations may help teachers and university managers consider the responsible use of Generative AI in teaching and learning. Because participants were recruited through non-probability convenience sampling, the findings represent the experiences and perceptions of the surveyed students only and should not be generalized to all university students in Pakistan.

Introduction

The rapid advancement of Generative Artificial Intelligence / GenAI has far-reaching consequences for modern teaching and learning systems in universities. GenAI is a different class of systems compared to traditional Artificial Intelligence (AI) technologies. Traditional AI automates tasks through a set of rules and predictive analytics. GenAI has the ability to generate

original content and produce human-like responses. GenAI translates languages, generates computer programming, and even helps learners in solving complex academic problems. With such capabilities, GenAI has truly transformed the educational landscape by making learning more accessible, engaging, and personalized. AI-enabled technologies are fast being integrated by universities in teaching, learning, curriculum design, learning support, and even research to optimize the quality of education and learning outcomes. GenAI is rapidly becoming the leading ed-tech for higher education systems. It helps learners get academic assistance when they need it, from anywhere. The rapid adoption of tools such as ChatGPT, Gemini, Microsoft Copilot, and Claude signifies the willingness by most stakeholders in the education sector to embrace AI as a tool that augments and supports the instructional process, as opposed to fully replacing it (Dwivedi et al., 2023).

The integration of generative AI into higher education has multiple drivers including digital learning, online education, and the personalization of learning. Modem Universities have ditched the traditional lecturing, teacher focused pedagogies for student centered educational structures that focus on flexible and cooperative learning, creativity, and independent construction of knowledge. Generative AI is an adaptive learning companion. Students have the ability to interact with AI to ask questions, request the rewriting of text to become simpler or to provide examples, get adaptive feedback, and view the topic from other angles. AI speeds up learning by taking away the barriers and slow pace of traditional learning. Generative AI is seen as the technology of the future by many Universities because of its ability to personalize learning and improve teaching effectiveness (Kasneci et al., 2023; Crompton & Burke, 2023).

Generative AI does more than help people find information. It changes the way people learn by helping them engage with their learning more deeply and learn advanced thinking skills. AI is different from a simple information retrieval tool. It helps users analyze ideas and different theories, generate research prompts, and construct and assess arguments through conversations. These skills stem from modern pedagogical theories that advocate for active participation in one's learning, as well as learning through questioning and helping to build and develop knowledge. The AI-infused classroom allows users to actively participate in their learning, engage in the learning process, and encourage iterative cycles. Many of the systems that use AI provide users with the ability to integrate learning, which helps users learn across different subjects. This helps prepare users for an ever-changing work world that continues to be differentiated by changing technologies. While many think that Generative AI is a tool, they are gravely mistaken. Generative AI has the ability to change the landscape of learning at the university level (Luckin & Cukurova, 2019; UNESCO, 2023).

Cognitive Engagement in Contemporary Learning Environments

Cognitive engagement is a vital aspect of any learning experience. It helps to assess the extent to which mental processes are fully utilized. This involves the use of higher order skills, self-regulatory practices, and active participation in the learning experience in order to create knowledge that is personally meaningful and relevant. As opposed to behavioral engagement which is concerned with presence and participation, or emotional engagement which deals with attitudes towards the learning experience, cognitive engagement is concerned with the depth of intellectual involvement during the processes of information assimilation, evidence-based problem-solving, and the synthesis of new knowledge with the old. Because of the central role cognitive engagement has on the learning process, it has been defined as one of the most important factors in determining the success of any learning experience. When there is a high level of cognitive engagement, there is also a high level of retention of information, as well as the development of critical and creative thinking. Moreover, cognitive engagement is foundational to the learning culture of any institution, and it is especially relevant to the evolving demands of the graduate labor market (Fredricks et al., 2019).

Cognitive engagement in students has evolved due to the digital transformation of education. Educational technology has a built-in preference for personalization. Students can adapt learning technologies to fit their academic needs. Learning is now an active process for students. Learning technologies can enhance virtual engagement, and can be integrated to promote discussion, probem-based learning, and AI-assisted concept exploration and tutoring. Learning technologies can provide learners with feedback, and help them to understand and monitor their learning and common misconceptions. This technology promotes deeper cognitive thinking, especially when students are encouraged to reflect on their thinking, evaluate different points of view, and relate learning to real-world contexts (Bond et al., 2020; OECD, 2021).

Generative AI promotes cognitive engagement by assisting the learner with the kind of thinking that requires analysis, evaluation, and the development of creativity and complex problem-solving. Cognitive technologies can provide personal and simplified explanations, and generate an abundance of examples. Contrary to popular belief, Generative AI technologies can promote engagement by encouraging learners to evaluate competing theories, and assumptions, and refine their understanding by questioning and engaging in dialogue. Constructivist theory of learning suggests that learning is an active process in which the learner is engaged in exploration and design. AI technologies have the potential to foster sustained cognitive engagement (Wang, S et al., 2026; Yan, L, et al., 2024).

Redefining Learning Experiences Through Generative Artificial Intelligence

Generative Artificial Intelligence (GenAI) is rapidly changing the higher education sector. We see a change in the way we package and deliver knowledge, as well as how it is consumed and utilized. Traditional university education has been largely dominated by instructor-led teaching approaches. In many cases, students' interactions with knowledge has been largely passive, characterized by lectures and/or readings followed by some form of standardized testing. This is however changing as generative AI has the potential to bring about transformation to more learner-centered educational ecosystems, emphasizing personalization, engagement, flexibility, and iterative feedback. The availability of generative AI systems reinforces students' learning outside the classroom by helping them both explain and elaborate instructional materials. Perhaps even more important, these systems provide students the ability to interact with both educational and instructional materials at their own pace and align to their own learning and cognitive styles and abilities. As the digital transformation of universities continues, generative AI is helping to improve the overall learning experience (Monzon et al., 2025; Qu, Y , et al., 2024).

Adapting to the individual needs of each learner has become a primary instruction method application of generative AI in education. Rather than trying to learn, as in the case of conventional methods, AI systems attempt to engage each Learner based on their virtual interactions with the system. Learners are able to request practice questions, clarifications on complex concepts, and even constructive feedback on assignments with the recommendations of learning resources based on the given performance. With AI educational systems, the learning process has become dynamic and self-instructive. Students learn concepts by interacting with the system, rather than passively observing. AI educational systems allow a social element to the learning process to be removed. This enables learners to work on difficult concepts multiple times without social barriers, found in traditional educational systems. This promotes academic self-efficacy by fostering a deeper understanding of concepts and improving overall engagement in school. (Ongesa Nyamboga, 2026).

Generative AI assists learners in developing higher-order cognitive skills and enables collaborative knowledge construction. Advanced AI systems push learners beyond the limits of simple answer retrieval. AI now supports an array of activities, including research, brainstorming, project work, academic writing, and coding. Furthermore, generative AI enhances multidisciplinary activity by extending its reach to multiple domains. AI invokes a constructivist view of learning by providing students the opportunity to develop knowledge and skills in an interactive manner. Additionally, generative AI supports organized group work, as students use the AI to help them brainstorm, facilitate classroom discussions, and complete research summaries. Learning becomes more stimulating and readying students for the unknown demands of the future workplace (Granda, B et al., 2024; Bond et al, 2020).

Research Objectives

- To examine the association between Generative Artificial Intelligence use and cognitive engagement among university students.
- To examine whether Generative Artificial Intelligence use and cognitive engagement statistically predict students' learning experiences.
- To examine the relationship between cognitive engagement and learning experiences among university students.

Research Questions

- What is the relationship between Generative Artificial Intelligence use and cognitive engagement among university students?
- How is Generative Artificial Intelligence use associated with students' learning experiences?
- What is the relationship between cognitive engagement and learning experiences among university students?

Problem Statement

The deployment of generative artificial intelligence (GenAI) in many aspects of higher education is changing how university students access information and perform academic-related tasks and how they interact with learning. GenAI may also provide opportunities for the personalization of learning, the immediacy of academic support, and the removal of barriers to education. The impact of GenAI on cognitive engagement and the learning experience of students is not clearly documented. Most of the available literature examines the adoption, ethics and effects of AI on the academic performance of students. There is little to no research on the impact of generative AI on students' engagement, critical thinking, deep learning, and participation within the university learning space. There is also a lack of research on the role of GenAI in cognitive

engagement and the learning experience of students in the higher education sector, especially in developing countries. This is a concern for educators and policymakers regarding the rational use of GenAI in teaching and learning within universities. The primary aim of this study is to examine the relationships among Generative Artificial Intelligence use, cognitive engagement, and students' learning experiences.

Significance of the Study

This study is important because it adds to the literature regarding the impact of generative artificial intelligence (GenAI) within the educational sector. It reviews GenAI's impact on cognitive engagement and learning experiences of university learners. The outcomes of this study can provide educators, university management, program designers, and educational policymakers with the practical and measurable evidence they need to construct AI-focused frameworks to nurture learning in the higher education sector. This study examines the use of GenAI and learning experience building to encourage engagement and teach learners to think critically, and constructively to personalize the learning experience while addressing the possible negative implications of using GenAI. This study aims to fill the gaps in the body of knowledge in the area of learning in the higher education sector of developing countries, and will provide targeted and purposeful AI learning engagements to improve learning and teaching outcomes.

Literature Review

Generative Artificial Intelligence (GenAI) has the potential to further disrupt the field of higher education. It creates new challenges and new opportunities for teaching, learning, and academic support. The expanding use of generative AI is unlike the way the earliest forms of AI were used. The beginnings of AI in the workplace involved automation of repetitive tasks through prediction and data analysis. Instead, the new forms of AI engage sophisticated deep learning frameworks and large learning constructs to produce text and images that resemble human creation and provide utility through the solution of complex, personalized, educational, and learning problems. Dwivedi, Yogesh K. et al. (2023), cite rapid developments in GenAI as a mechanism for universities to build smart, highly effective, and adaptive educational technologies to support teaching, learning, and research. Likewise, Kasneci, Enkelejda et al. (2023) claim the use of large language models, including ChatGPT, represents a highly significant change within higher education in that students can now receive real-time and personalized educational and learning support which extends beyond the conventional classroom and deeply interactive instructional frameworks. The use of GenAI is clearly demonstrating that it is becoming a core element of the rapidly transforming Digital Education and is changing not only the support of the learning process, but how learning, teaching, and the support of educational processes is done.

In higher education, the rise of generative AI has led to more use cases of personalized, student-centric learning. Zawacki-Richter, Olaf et al. (2019) explain that AI technologies can create adaptive learning environments by examining the educational needs of learners and, therefore, designing instructional content geared toward the learner to help them improve their educational and learning efficiencies. Generative AI builds on this by enabling students to engage with an intelligent system that can hold conversations in natural language, give real-time feedback on homework, design learning activities (from exercises to practice problems), summarize educational literature, and assist in articulating complex learning concepts. According to Crompton, Helen, and Burke (2023) adaptive, AI-based educational technologies promote self-oriented learning by encouraging students to learn at their own pace, with customizable depth and learning activity sequencing, and greater flexibility in digital learning. This student-centric learning model is aligned with modern theories of education focused on developing and facilitating learning that incorporates active participation, individual autonomy, and the construction of personalized knowledge over the retention and acquisition of knowledge.

Aside from helping students, generative AI has resulted in modifications relating to how teaching and learning occur in the university setting. The use of AI, particularly in teaching and learning, has been further documented by Pushpanadham, K et al., (2024) on how various higher education institutions have used generative AI in service of developing their academic curriculum, automating administrative tasks, developing their teaching/learning materials, managing their e-learning platforms, and developing their student support services. The use of AI by teaching staff in the workplace has enabled them to generate teaching/support materials, create assessment items, and develop case studies. The use of generative AI has become increasingly focused on improving support services, developing new and innovative ideas, research, and coding within the academic/learning space, as well as assisting students in a variety of ways, such as providing translation support and creating new and innovative research ideas across various academic disciplines. As stated by Rahman, G et al., (2025), the most recent generation of intelligent educational technologies, coupled with AI, has resulted in the successful creation of learning environments that support collaboration and the generation of higher-order thoughts.

Generative Artificial Intelligence and Cognitive Engagement

Cognitive engagement is when students use higher order thinking and act to better understand something, which helps them to remember what they have learned. This goes beyond simply participating in class. Cognitive engagement is when students are ready to analyze data, solve new problems, and reflect on their learning and how to control their own learning. Rapid growth in Generative Artificial Intelligence (GenAI) has changed the way students in higher education engage with academic work in a new way. Wu, Y et al. (2026) argue that with the use of Generative AI, students receive personalized answers and real time learning assistance and feedback on how to develop and work with a given academic idea. García-Peñalvo (2023) argue that real cognitive engagement is when students create their own knowledge because of the active learning process the AI learning system has created, and not because the information was given to them.

Generative AI brings customizable learning to students by evaluating their needs and strengthening their skills through various means of advanced engagement. This technology stands apart from traditional methods which use universal instructional content. AI-Learning systems are capable of adapting and optimizing lesson plans, providing study materials, and practicing real-time problem solving with students. Yau, N et al., (2026) argue that learning through personalized AI has students operating on their own timelines and causes them to actively engage more with the learning process by encouraging individual critical thinking. It has also been shown that technology focused on digital learning causes students to think more critically and become more engaged by causing them to partake in active discussions and deep thinking through collaborative work (Levin, I et al., 2025). With generative AI, the dialog between learner and system does not cease, and therefore, students are capable of continuously changing their perspectives, examining multiple lines of reasoning, and thinking critically about the concepts being discussed.

Generative AI illustrates another linear aspect to cognitive engagement by helping users with higher-level thinking skills such as critical thinking, analysis, creativity, and complex problem-solving. Testa, M et al., (2025) argue that AI can act as a cognitive partner that expands the thinking ability of learners, rather than just filling the answers to learners' questions. AI systems' interactive dialogue reinforces students' abilities to compare theories, brainstorm, evaluate, synthesize, and defend their answers. These activities also reflect a constructivist theory of learning, as they enable learners to build knowledge through cognitive and physical engagement with their environments. In addition, Naseer, A et al. (2026) claim that generative AI promotes deeper learning by enabling students to revise their understandings and recognize and correct their misconceptions and offering immediate formative feedback to promote sustained and deeper learning in higher education contexts.

Generative Artificial Intelligence and Learning Experiences

Learning experiences in higher education deal with the cognitive, emotional, and interactive elements involved in the learning process. These experiences deal with the acquisition of skills and the construction of understanding. Traditionally, learning experiences have revolved around face-to-face contact, printed learning resources, and standardized instruction. However, with the emergence of Generative Artificial Intelligence (GenAI), learning experiences have undergone even greater modification with the introduction of intelligent, interactive, and adaptive learning experiences. According to Consolacion, R et al. (2026), generative AI is now among the most disruptive technologies in education since it allows the learner to receive on-demand, in and out of class support, creates learning content, and provides customized scaffolding, permitting the learner to engage in learning beyond the traditional confines of the classroom. Likewise, Howard, T et al., (2025) observes that the proliferation of generative AI in the higher education sector has not only improved access and flexibility in the learning process, but has also enabled higher learning institutions to design more accommodating, inclusive, and student-centered learning models that address varied learning needs.

Generative AI has the potential to reshape learning experiences through the personalization of instruction. It can now account for students' learning styles, cognitive and knowledge structures, and even their rate of learning. Traditional teaching methods have to rely on the use of instructional content that is mostly the same for all students. However, learning systems that utilize AI have the potential to provide personalized learning through the generation of customized responses, learning paths that adapt to students' needs, and the provision of instant feedback. Generative AI opens the opportunity for students to ask as many academic questions as they wish. They can also receive clarifications, generate their own examples, and even optimize learning by summarizing bite-sized learning constructs. In addition to the above, personalized AI-supported learning systems further improve learning satisfaction of the students by increasing the accessibility, and providing autonomy and opportunity for active participation. A major benefit of personalized learning systems is the improvement of learning confidence and the mastery of the learning content.

Higher education learning environments are increasingly interactive and cooperative as a result of the use of Generative AI, and this is likely to remain the case. Jou, M et al. (2026) argue that digital educational technologies are beneficial to learning

when they encourage participation in discourse, solving real-world problems, engagement in cooperative activities, and metacognitive reflection. Generative AI supports all of the above, in addition to brainstorming, project building, writing, research, coding, and collaborative knowledge building, to name a few. Students are able to interact with AI systems in order to assess a variety of viewpoints, polish research ideas, generate a range of solutions, and partake in substantive discourse that furthers academic curiosity. Iqbal, J et al., (2025) suggest that the role of AI in education should be analogous to a partner in the learning process, assisting in the exploration and cultivation of creative and critical thought, as opposed to the traditional role of an information bearer. For this reason, learning becomes more flexible and stimulating, and students are more likely to be motivated while being encouraged and supported in taking control of their own learning.

Research Gap

Current research regarding Generative Artificial Intelligence (GenAI) in higher education focuses on adoption, capabilities, ethics, and pedagogical implications. While this research is very important, there are still gaps. Most of the research studies have centered on the acceptance of AI, on the performance of students in the classroom, the efficiency of learning, and the intention of students to use AI technologies. There is limited research examining the relationships between generative AI use, cognitive engagement, and students' learning experiences. Additionally, many of the studies have been conducted in developed nations. The results of these studies cannot be applied to the higher education systems of developing nations where the technology and the practices of education differ greatly. Many of the previous studies have also focused on cognitive engagement, or the learning experience separately. There is very little research on the combined relationship of cognitive engagement and the learning experience within AI Learning Environments. Consequently, limited evidence is available regarding these relationships, particularly in developing-country university contexts. This research focuses on learning experiences and cognitive engagement of university students with Generative Artificial Intelligence. The goal of this research is to provide evidence that will aid educators and policymakers to design AI-centered pedagogical frameworks with quality learning and teaching strategies.

Research Hypotheses

H1: There is a significant positive relationship between Generative Artificial Intelligence and cognitive engagement among university students.

H2: Generative Artificial Intelligence use and cognitive engagement significantly predict learning experiences among university students.

H3: There is a significant difference in perceptions of generative artificial intelligence, cognitive engagement, and learning experiences based on gender among university students.

H4: There is a significant difference in perceptions of generative artificial intelligence, cognitive engagement, and learning experiences across different age groups among university students.

Conceptual framework

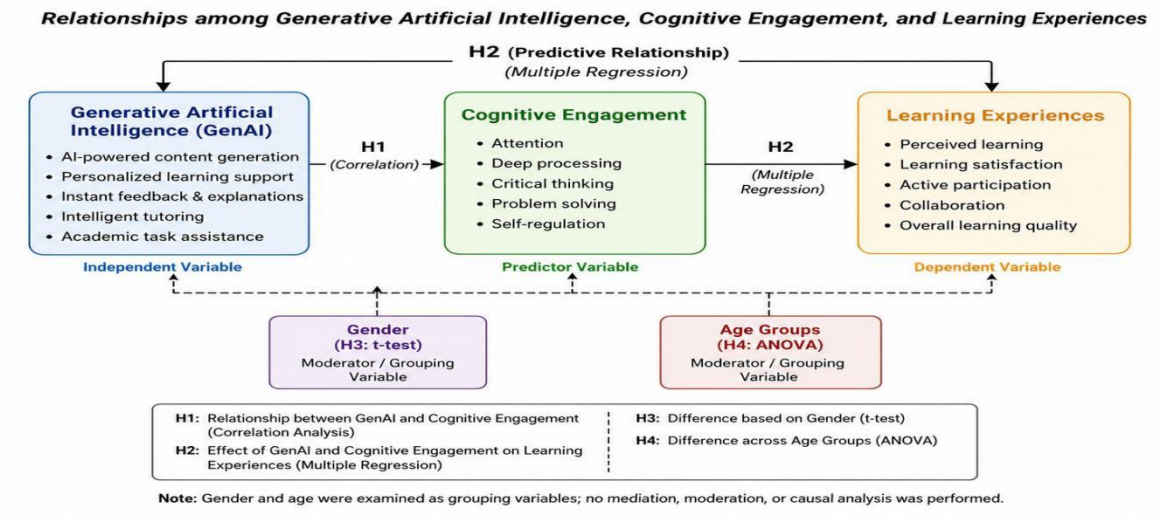

Figure 1: Conceptual framework

Methodology

Research Design

With its emphasis on observing phenomena as they exist and the ability to derive deep meaning from numbers, this study utilized a quantitative approach. The researcher's ability to define relationships between Generative Artificial Intelligence (GenAI), cognitive engagement, and learning experiences was made easier through the collection of university students' responses in numerical formats. The data collection instrument was a structured questionnaire. Researchers and statisticians, alike, preferred this instrument as it provided a consistent definition and description of variables. The cross-sectional aspect of this research was highly efficient, as data were collected at one point in time. This aspect was important, as the objective of this study was to obtain university students' perceptions on the role of generative artificial intelligence within the education system. Data were gathered at a single moment in time, so the study can only establish statistical relationships. It does not describe these relationships in direction or show that Generative Artificial Intelligence led to changes in cognitive engagement or learning experiences.

Population

The target population of this study was undergraduate and postgraduate students from public and private universities in the Punjab and Sindh provinces of Pakistan. These provinces were selected because they contain the largest higher educational sectors in the country and have seen the recent growing use of digital learning technologies and artificial intelligence in the university education sector. Sampled students were from the University of the Punjab (Lahore), Bahauddin Zakariya University (Multan), Islamia University of Bahawalpur, Government College University Faisalabad, University of Education Lahore, University of Engineering and Technology Lahore, University of Sargodha, COMSATS University Islamabad (Lahore Campus), National University of Computer and Emerging Sciences (FAST-Lahore), Shah Abdul Latif University Khairpur, University of Sindh Jamshoro, Mehran University of Engineering and Technology Jamshoro, Sukkur IBA University, NED University of Engineering and Technology Karachi and University of Karachi. These universities were selected in the study because students actively engage with digital technologies and AI-based educational tools in their studies.

Target Audience

The target audience were university students who had either used Generative Artificial Intelligence in the education sector and/or who had undertaken undergraduate, graduate and or postgraduate studies. Students from the areas of the management sciences, computer sciences, engineering, social sciences, education, business administration, economics, information technology, and natural sciences were all included. It was anticipated that the respondents would be knowledgeable enough and have the background so they could engage with cognitive educational AI tools like ChatGPT, Google Gemini, Microsoft Copilot, Claude and others, to discuss their learning experiences.

Sampling Technique

The study used non-probability convenience sampling technique in which the participants of the study were students of a university who were student and academic communication platforms available online. The participants were selected based on their availability, willingness to participate, enrollment in a required university, and previous educational experiences with Generative Artificial Intelligence. The questionnaire was sent using University related e-mail chain, Whatsapp group, Facebook group and other online student platform. This strategy allowed a relatively large number of respondents to be reached within the time and resources constraints, but did not guarantee an equal chance of being selected for all the students in the target population. Thus, the sample may not represent all university students in Punjab, Sindh, or Pakistan.

Sample Size

The total sample of respondents were 433 students of undergraduate and postgraduate courses from the selected public and private universities of Punjab and Sindh. The sample size exceeded the minimum number needed to be used in the statistical techniques used in the study such as Pearson correlation, multiple linear regression, independent-samples t-tests and one-way ANOVA. However, a large sample does not overcome the limitations of convenience sampling. Thus, statistical sufficiency, for conducting analyses, does not imply a representative sample of the general population of university students in Pakistan.

Data Collection

Employing a cross-sectional approach, primary data were collected using a structured and pre-validated questionnaire, which was segmented into four sections. The initial section gathered demographic data including respondents' gender, age,

educational level, and their affiliated university. The second section employed an adapted scale of Khlaif, Z et al. (2025) and assessed respondents' educational use of Generative AI. The engagement section incorporated an adapted version of the Student Engagement Scale developed by Fredricks et al. (2019). Finally, the last section included an adapted version of the studies by Munenakoppa, M et al. (2026) which focused on the assessment of students' perceptions of learning within technology-mediated instructional environments. The last section measured the students' learning experiences.

All statements in the questionnaire were measured on a five-point Likert scale. The measures captured students' self-reported perceptions and experiences rather than objectively observed AI use, cognitive behaviour, or academic performance. The questionnaire was posted on Google Forms with the survey link distributed electronically via university emails, WhatsApp, Facebook, and other online student platforms. Data collection was conducted across multiple university campuses in Punjab and Sindh. Participation was voluntary, and respondents had the option to complete the research using their smartphones, tablets, or personal computers.

Ethical Considerations

All voluntary participants completed the questionnaire after giving their informed consent. Respondents realized the reasons behind the study and understood the confidentiality and anonymity of their responses. Researchers did not collect any data that could lead to the identification of the respondents. Anonymity was maintained to reduce respondents' pressure to provide socially desirable answers; however, such bias could not be completely eliminated. The data were used for academic research only. Respondents were aware of their right to exit the survey whenever they wanted without any consequences. Researchers continued to uphold the right to exit the survey even after data were collected. Researchers used the data for exclusively statistical purposes. Respondents' right to exit the survey and the right to confidentiality were also upheld in the publication of the research.

Data Analysis

All responses were first entered into a Microsoft Excel spreadsheet to prepare for data screening, entry, and organization. Responses were then imported into the Statistical Package for the Social Sciences (SPSS) for data analysis. The software was used to run some calculations in order to find some descriptive statistics.

Pearson correlation analysis was used to establish the nature of the relationship (positive or negative) and the strength of the relationship (strong or weak) between Generative Artificial Intelligence and cognitive engagement. Multiple linear regression was performed to examine whether Generative Artificial Intelligence use and cognitive engagement statistically predicted students' learning experiences. An Independent Samples t-test was used to check for differences in the study variables based on the gender of the respondents. A One-Way Analysis of Variance (ANOVA) was performed to check for differences in the perceptions of Generative Artificial Intelligence, cognitive engagement, and learning experiences, among the different age groups. The results were shown in tables and interpreted using their statistical significance to provide evidence for the study.

Table 1: Demographic Characteristics of Respondents (N = 433)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	228	52.7
	Female	205	47.3
Age	18–22 Years	161	37.2
	23–27 Years	172	39.7
	28–32 Years	71	16.4
	Above 32 Years	29	6.7
Educational Qualification	Undergraduate (BS)	187	43.2
	Master's (MS/MPhil)	163	37.6
	PhD	83	19.2
University Type	Public University	276	63.7
	Private University	157	36.3
Province	Punjab	279	64.4
	Sindh	154	35.6
Frequency of Using Generative AI	Daily	126	29.1

Demographic Variable	Category	Frequency (n)	Percentage (%)
	Several Times a Week	158	36.5
	Once a Week	92	21.2
	Occasionally	57	13.2
Total Respondents		433	100.0

The demographics of the study's 433 respondents showed a near equal gender representation with 52.7% male and 47.3% female. The largest group, 39.7%, was 23 to 27 years of age, followed by the 18 to 22-year group at 37.2%. The remaining respondents were 28 to 32 years of age (16.4%) and over 32 years of age (6.7%). The largest educational group was undergraduate students (43.2%) followed by Master's students (37.6%) and PhD students (19.2%). Most respondents were students in public universities (63.7%) compared to students in private universities (36.3%). The majority of the respondents (64.4%) resided in Punjab while the rest (35.6%) were in Sindh. When respondents were questioned about the use of generative artificial intelligence for educational purposes, most respondents said they used AI several times a week (36.5%), while almost a third were daily users (29.1%). This indicates that the use of generative AI as an educational technology is prevalent among the university students surveyed in this study.

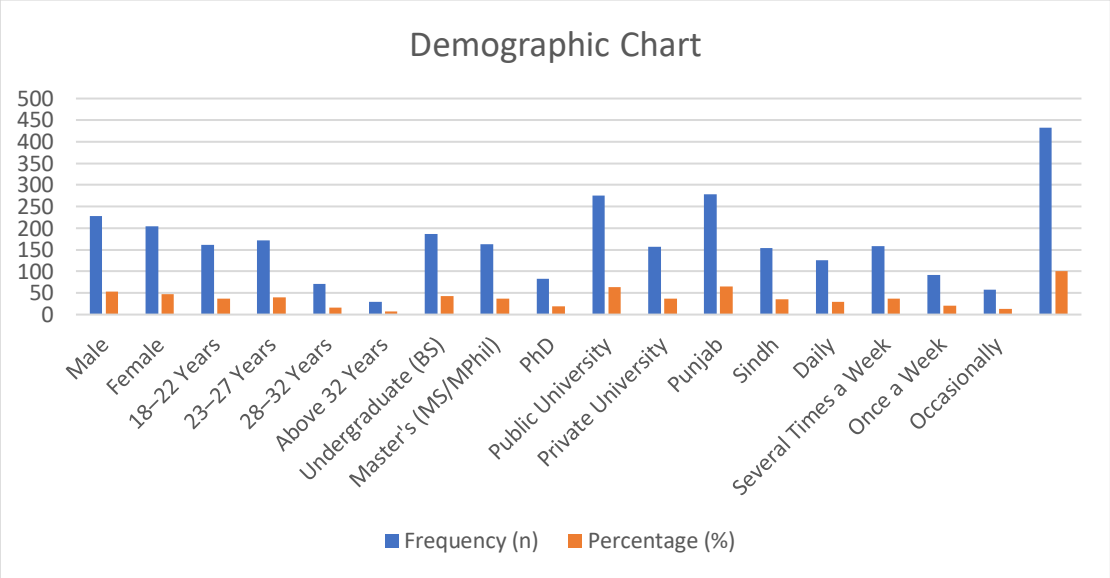

Figure 2: Demographic Characteristics of Respondents

Table 2: Relationship between Generative Artificial Intelligence and Cognitive Engagement (N = 433)

Variables	Mean	SD	1	2
1. Generative Artificial Intelligence	3.91	0.67	1	
2. Cognitive Engagement	3.84	0.71	.684**	1

Presents the findings of the Pearson correlation analysis on the interrelationship of Generative Artificial Intelligence and cognitive engagement of university students. The analysis shows that Generative Artificial Intelligence and cognitive engagement have a strong positive relationship and that the correlation is significant at the .001 level (r = .684). The positive correlation indicates that students reporting greater Generative Artificial Intelligence use also tended to report higher cognitive engagement; however, it does not establish direction or causation.

Table 3: Predictive Relationships of Generative Artificial Intelligence and Cognitive Engagement with Learning Experiences (N = 433)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.801	.642	.640	.418

ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	132.764	2	66.382	379.541	.000
Residual	75.206	430	.175		
Total	207.970	432			

Coefficients

Variables	Unstandardized B	Std. Error	Standardized Beta	t	Sig.
(Constant)	.624	.173		3.607	.000
Generative Artificial Intelligence	.421	.051	.438	8.255	.000
Cognitive Engagement	.452	.049	.489	9.221	.000

Table 3 presents the multiple regression predicting learning experiences from Generative Artificial Intelligence use and cognitive engagement. The model was statistically significant, $F(2, 430) = 379.541$, $p < .001$, and explained 64.2% of the variance. Generative Artificial Intelligence use ($\beta = .438$) and cognitive engagement ($\beta = .489$) were significant positive predictors, with cognitive engagement showing the stronger association. The remaining 35.8% may reflect unmeasured factors such as digital literacy, motivation, academic achievement, technological access, field of study, and socioeconomic background. Because the data were cross-sectional and self-reported, these findings indicate statistical prediction rather than causation.

Table 4: Gender Differences in Generative Artificial Intelligence, Cognitive Engagement, and Learning Experiences (N = 433)

Variable	Gender	N	Mean	SD	t-value	Sig. (2-tailed)
Generative Artificial Intelligence	Male	228	3.96	0.66	2.143	.033
	Female	205	3.82	0.69		
Cognitive Engagement	Male	228	3.89	0.71	2.027	.043
	Female	205	3.75	0.72		
Learning Experiences	Male	228	4.01	0.61	2.284	.023
	Female	205	3.87	0.64		

Results from the Independent Samples t-test examining gender differences show that Male participants score means of GAI, ($M = 3.96$, $SD = 0.66$), and Female participants, ($M = 3.82$, $SD = 0.69$). Male participants also appear to score means that are higher for Cognitive Engagement ($M = 3.89$, $SD = 0.71$) compared to Female participants ($M = 3.75$, $SD = 0.72$), and $t = 2.027$, $p = .043$. GAI and Cognitive Engagement score means reveal significant gender differences, and $t = 2.284$, $p = .023$, show significant gender differences in Learning Experiences, with Male participants reporting ($M = 4.01$, $SD = 0.61$) and Female participants reporting ($M = 3.87$, $SD = 0.64$). As all values were below .05, there were statistically significant differences between males and females in three areas: Generative Artificial Intelligence use, cognitive engagement, and learning experiences. Thus, H3 was supported.

Table 5: Differences in Generative Artificial Intelligence, Cognitive Engagement, and Learning Experiences Across Age Groups (N = 433)

Variable	Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Generative Artificial Intelligence	Between Groups	5.864	3	1.955	4.912	.002
	Within Groups	170.720	429	0.398		
	Total	176.584	432			
Cognitive Engagement	Between Groups	4.917	3	1.639	3.756	.011
	Within Groups	187.141	429	0.436		

Variable	Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
	Total	192.058	432			
Learning Experiences	Between Groups	6.283	3	2.094	5.284	.001
	Within Groups	170.046	429	0.396		
	Total	176.329	432			

Reports the outcomes of a One-Way Analysis of Variance (ANOVA) used to identify variances in perceptions regarding Generative Artificial Intelligence, cognitive engagement, and learning experiences among age-based cohorts of university students. Results show that the age cohorts exhibited distinct differences in their perceptions regarding Generative Artificial Intelligence ($F = 4.912$, $p = .002$). Thus, the different age groups of university students engaged with AI technologies for learning in different ways, and also had different AI technology perceptions. In the same way, engagement of the age cohorts exhibited a statistically significant difference as well ($F = 3.756$, $p = .011$). Therefore, cognitive engagement of university students and the degree of participation in the learning process also varied with the university students' age. Learning experiences as well were different among the age groups ($F = 5.284$, $p = .001$). This shows the educational experiences of the age groups of university students interacting with Generative Artificial Intelligence also differed. Because all significance values were below .05, mean scores differed significantly across age groups; however, the results do not show that age caused these differences.

Discussion

This study examined the relationships among Generative Artificial Intelligence use, cognitive engagement, and learning experiences. Positive associations were identified within the surveyed sample, but the results do not demonstrate that Generative Artificial Intelligence caused improvements. Because all variables were measured through the same self-report questionnaire, the relationships may partly reflect social desirability, response tendencies, or common-method bias.

The result of the correlational study found a strong positive relationship between Generative Artificial Intelligence tools and cognitive engagement of university students. Findings showed that students who are more inclined to use AI-based educational tools engage in more active critical thinking and mental effort during the learning process, and that students display greater active involvement and a greater level of engagement during learning activities. The findings are similar to those of Nikolopoulou, K. (2025). Kasneci et al. argued that language learning models contain the potential to deepen students' learning by delivering explanations, adaptive feedback, and exercises tailored to the students' particular learning needs. Findings are also consistent with the beliefs of Mohamed, F et al. (2025) who emphasized that learners cognitively engage through self-regulated learning and active participation and that learning environments augmented with instructional technology enhance sustained cognitive engagement through active participation and collaboration. The findings of this study suggest that the responsible application of generative AI in the context of higher education would provide a reliable cognitive support system to active learners.

The regression analysis indicated that Generative Artificial Intelligence use and cognitive engagement were positively associated with students' learning experiences. Of the predictors, cognitive engagement had a stronger impact than Generative Artificial Intelligence. Therefore, it can be said that the deeper the students' cognitive engagement is, the more learning experiences students are likely to benefit from the use of AI technologies which are not only information providing. These findings are consistent with the study of Nedungadi, P et al. (2024), which stated that the learning value of generative AI relies on the furtherance of meaningful learning and not the performing of learning tasks. Likewise, in the AI-enabled learning systems, Bozkurt, A et al., (2024) noted that learning is improved through the provision of adaptive learning, feedback, and instruction, and learner-centered activities. The current findings extend the observations of Vendrell, M et al., (2026), who argued that there is potential for generative AI to enhance learning when it is incorporated in teaching and learning systems designed to foster engagement, creativity, and critical thinking. Thus, positive relationships between the use of Generative Artificial Intelligence and cognitive engagement and learning experiences have been established in the context of the students of the selected universities of Punjab and Sindh.Therefore, the present study provides context specific evidence of positive relationships between G.A.I. use, cognitive engagement and learning experiences among the students of the survey universities of Punjab and Sindh. However, 35.8% of the variation in learning experiences was not explained by the model. This suggests that other factors outside the scope of the current study that may impact on the relationships between variables, such as students' pre-test digital literacy, intrinsic motivation, prior academic achievement, access to digital resources, and discipline, could also have been a factor.

The Independent Samples t-test showed significant statistical gender differences regarding perceptions of Generative Artificial Intelligence, cognitive engagement, and learning experiences. In all areas covered by the research, male students had

higher mean scores. These findings should not be ignored, as male students indicated that they had significantly higher scores on the Generative Artificial Intelligence use, cognitive engagement and learning experiences. From the results, it is concluded that gender-related differences are still relevant in the contexts studied in the university. These disparities could be related to access to digital technologies, past exposure to AI, confidence with digital technologies, field of study or social and institutional opportunities. The possible explanations listed above are not directly measured, though, and need to be included in future research. Punjab and Sindh universities should explore the challenges faced by the female students and ensure that they have access to equal opportunities with regard to the use of AI tools, training in digital-skills, technical support, and access to AI supported learning opportunities.

The One-Way Analysis of Variance (ANOVA) revealed differences among age groups in relation to Generative Artificial Intelligence, cognitive engagement, and learning experiences. Findings indicate that students of different age groups may perceive AI-assisted learning differently due to different levels of technological engagement, teaching experience, digital self-efficacy, and learning styles. It is likely that younger students are more flexible in their use of new learning technologies due to the greater presence of digital technologies in their learning experiences. This has also been stated by Wegerif, R et al., (2026), which argued that students' digital skills and past interactions with technology influence their ability to learn within AI-assisted pedagogical frameworks. Alhitty, A (2026) indicated that students' age and other social and demographic characteristics influence their acceptance of Artificial Intelligence technologies and their use of these technologies in learning. The current findings therefore extend previous studies and indicate that age continues to play a significant role in students' learning experiences in AI-enabled learning frameworks.

As far as Punjab and Sindh is concerned, the findings show that currently, G.A.I. is a common phenomenon in the academic life of many students as 65.6% of the students surveyed said that they use it daily or several times in a week. But it is clear that AI-enabled learning is not an equal experience, as there are significant differences in gender and age. In both provinces, thus, universities should integrate access to AI tools with digital-literacy training, enabling of the female students and institution-specific information on responsible academic use of AI. As inferential analysis was not accomplished for province, it is not possible to conclude that there is any difference between Punjab and Sindh.

The results of this study likely support more literature naming Generative Artificial Intelligence as an innovative educational technology that supports the development of the higher educational system. Hamad, W et al. (2026) observed that AI evolved from administrative support to intelligent educational technologies that enhance the teaching process, the assessment, and the support, and personalization of the learning process. Luckin and Cukurova (2019) suggested that AI should function as a cognitive partner rather than replace human intelligence. The present findings are consistent with this view and suggest that Generative Artificial Intelligence may support active learning and cognitive engagement when used appropriately, although no causal conclusion can be drawn.

Conclusion

This study explored the use of Generative Artificial Intelligence (GenAI) to augment cognitive engagement and reshape learning for university students. Evidence suggested that generative AI is becoming a powerful educational technology for facilitating active learning, personalization, and substantive engagement in higher education. Results from the statistical analyses showed a substantial positive correlation between Generative Artificial Intelligence and cognitive engagement. The regression analysis indicated that Generative Artificial Intelligence use and cognitive engagement were significantly associated with students' reported learning experiences. Additionally, the results of the t-test and one-way ANOVA showed that the perceptions of Generative Artificial Intelligence, cognitive engagement, and learning experiences differentiated significantly by gender and age. The responses of male respondents were significantly higher than female respondents on all three variables indicating that the differences between male and female respondents should be taken into consideration in developing the locally responsive AI strategies for university in Punjab and Sindh. These strategies should take account of variations in digital readiness, socio-cultural and demographic contexts and access to technology within institutions. In general, the higher the use of Generative Artificial Intelligence, the higher were the level of cognitive engagement and the positive learning experiences of the students surveyed of the selected universities; however, the results should not be inferred as applicable to all universities in the Pakistani higher education system. The findings suggest that Generative Artificial Intelligence may support more personalized and learner-centred environments, although its effects require longitudinal or experimental evaluation. Although there are numerous benefits from generative AIs in education, their successful application will depend on their intentional ethical use from both the educator and the learner. As such, universities must adopt a balance between engaging with AIs, promoting learning technologies, and reinforcing critical thinking, academic integrity, and digital literacy, such that AIs add to learning rather than detract from it. The results presented will help to support the growing body of literature pertaining to the role of artificial intelligence as a tool to be integrated into higher education. The outcomes might offer preliminary and region-specific information for teachers, university managers and policy makers in the involved

regions. But, more policy decisions should be based on probability based studies covering a wider section of the universities, disciplines, socioeconomic sections and geographical areas of Pakistan. These findings should not be interpreted as evidence of causation.

Limitations of the Study

There are a number of limitations of this study. The participants of the study were sampled using non-probability convenience sampling and online platforms, and as such the sample may be problematic as it may overrepresent students who are digitally active or already familiar with Generative Artificial Intelligence. The respondents were selected from a few universities in Punjab and Sindh but the results are not statistically representative of all the university students of the provinces or Pakistan.

Second, the cross-sectional design identifies associations but cannot establish temporal order or causality. Additionally, data from self-reported questionnaires were used in the study, and this may be subject to social desirability, recall errors, personal interpretation and common-method bias. Thus, the results are based on the students' stated perceptions and not their own behaviour or the students' academic results. Lastly, the regression model accounted for 64.2% of the variance in learning experiences with the remaining 35.8% of variance not accounted for. The results could be influenced by unmeasured factors like digital literacy, intrinsic motivation, academic achievement, technological access, socioeconomic background and field of study.

Recommendations

1. Universities should pilot Generative Artificial Intelligence-supported teaching activities and evaluate their outcomes before wider implementation.
2. Faculty members should receive regular training on the effective and ethical use of generative AI technologies in higher education.
3. Universities in Punjab and Sindh should develop institution-specific AI policies, digital-literacy training, and equitable access measures suited to their students' needs.
4. Students should be encouraged to use generative AI as a learning support tool while maintaining critical thinking, creativity, and academic integrity.
5. Higher education institutions should organize AI literacy workshops to improve students' and educators' digital competencies and awareness of AI applications.
6. Universities should invest in AI-supported learning platforms and digital infrastructure to provide equitable access to advanced educational technologies.
7. Future studies should take a probability based sampling approach and sample universities from other provinces in order to better represent and generalize the results.
8. Future research should include the subjective data collected from questionnaires along with other objective data like history of AI use, academic outcomes, observations, and interviews.
9. Future research should involve: digital literacy, motivation, academic achievement, technological access and socioeconomic status in advanced statistical models.
10. Universities need to identify gender disparities in access to AI tools, digital-skills training opportunities, mentorship and technical support, and ensure that female students have equal access.

Future Implications

This study lays the groundwork for further research and changes to education. These changes center around the addition of Generative Artificial Intelligence (GenAI) to the higher education system. AI continues to innovate. The future may bring more sophisticated, personalized, and adaptive learning systems, which aid cognitive growth and learning in the university setting. Future research may analyze the consequence of generative AI and its impact on academic success, creativity, critical thinking, mental health, self-regulation, digital literacy, and overall well-being in various educational fields and cultures. In addition to the above research, other studies will likely focus on the educational influence of AI through the use of longitudinal, mixed methods, and experimental research. It is important to keep the above research interests in mind when developing teaching methods. Creating ethically sound teaching methods and digital citizenship programs to use generative

artificial intelligence safely while enhancing the learning experience and improving the preparedness of students to meet the requirements of a rapidly evolving, technology-reliant world is extremely important for policy makers and higher education institutions.

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