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The Rise of AI-Augmented Cognition in Education: Examining Financial Awareness, Learning Engagement, and Students' Academic Development

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ARTICLE INFO	ABSTRACT
Submission: July 09, 2026 Revised: July 25, 2026 Accepted: August 10, 2026 Available Online: August 24, 2026 Keywords: <i>AI-augmented cognition, generative artificial intelligence, financial awareness, learning engagement, academic development, higher education, university students, AI-supported learning.</i> Corresponding author: Imran Mughal Email: imran.saif3529@gmail.com	The rapid integration of artificial intelligence (AI) into higher education is reshaping how university students access information, engage with learning, and develop academic competencies. However, limited empirical research has examined AI-augmented cognition as a broader educational phenomenon connecting students' cognitive use of AI with both academic and practical outcomes. This study examined the relationship of AI-augmented cognition with financial awareness, learning engagement, and students' academic development among university students in Pakistan. A quantitative cross-sectional research design was adopted, and data were collected from 467 university students enrolled in higher education institutions across Punjab and Sindh, Pakistan. An adapted structured questionnaire containing established measures of AI-augmented cognition, financial awareness, learning engagement, and academic development was administered through Google Forms, and the survey link was distributed electronically to eligible respondents through academic and student networks. The collected responses were organized and screened before being analyzed quantitatively to examine relationships, predictive patterns, and differences among relevant student groups. The findings revealed that AI-augmented cognition was positively associated with financial awareness, learning engagement, and students' academic development, with the strongest relationship observed with academic development. AI-augmented cognition also demonstrated a meaningful predictive contribution to all three outcomes, indicating that students who engaged more actively with AI as a cognitive resource tended to report greater financial awareness, stronger learning engagement, and enhanced academic development. Furthermore, students with previous generative AI experience demonstrated comparatively higher levels of the major study variables, while differences were also observed across varying levels of AI-use frequency. These findings highlight that the educational significance of AI extends beyond technological adoption and conventional academic assistance, suggesting that purposeful AI use may support students' cognitive development, engagement with learning, and practical awareness of financial matters. The study contributes to the emerging literature by positioning AI as a cognitive augmentation resource rather than merely a digital learning tool and provides practical implications for higher education institutions seeking to promote AI literacy, critical evaluation, responsible AI use, and meaningful student development.

Introduction

Technological advancements like generative AI (GenAI) continue to make rapid progressions in the modern educational landscape, such as how students can access and process knowledge, how students can engage with and solve academic problems, and how students can complete academic tasks. Once widely accessible systems like ChatGPT, Gemini, and other generative systems were created, AI technologies became interactive resources that students could use to explain concepts, give examples, provide feedback, assist in generating solutions and problem-solving activities, and assist in other activities of instruction. GenAI has become a support system and a cognitive resource for students. This has resulted in a learning framework in which students use intelligent technology to change and amend their approaches to learning, as opposed to relying solely on conventional teaching and learning resources. From the available literature, the use of GenAI has a positive impact on the academic performance of university students and promotes higher-order thinking while enhancing motivational and affective states, although the impact varies considerably within a particular context of instructional design, the characteristics of learners, the type of AI Technology, and the kind of learning strategies employed (Chen & Cheung, et al., 2011; Han et al., 2025).

The use of AI in education has the potential to enhance and change not only how students learn, but also how they construct knowledge and govern/regulate their learning processes. In most conventional teaching and learning contexts, helping students learn involves presenting knowledge in the form of teachers and textbooks, and using learning resources that the institution offers. In contrast, AI-supported learning offers students the ability to ask questions, get answers and explanations, check answers, receive feedback, and review challenging concepts. In this case, AI can act as a cognitive scaffold and assist students as they participate in higher-order activities within their academics. A recent systematic review analyzed pedagogical applications of GenAI and noted an emphasis on creativity, critical thinking, learning autonomy, and prompt literacy, while noting a concern of overreliance on AI leading to a circumvention of critical and metacognitive thinking (Qian, 2025). This demonstrates the importance of prompt use of AI within the classroom in an advanced cognitive task, reflective, and independent learning context.

Learning Engagement and Students' Academic Development

AI-assisted techniques have the potential to alter many different dimensions of students' academic development, including learning engagement. As the name suggests, learning engagement is about students' cognitive investment, as well as their behavioral and emotional participation and contribution to the learning process. AI learning systems may be able to increase learning engagement by making learning more interactive, more responsive, and more individually tailored. Meta-analyses show that GenAI promotes students' motivation as well as their cognitive and emotional engagement directly involved in the learning process, and these effects seem to be related to learning strategies, academic disciplines, and the context in which AI is implemented (Chen et al., 2025). Likewise, GenAI-based interventions may also improve learning outcomes, although they have, so far, been implemented in a limited number of educational institutions (Ganesh Iyer, 2024). Thus, students' academic development will depend on more than just the use of AI. It will also depend on the extent to which learning activities employing AI promote students' active participation, self-regulation, and analytical thinking and engagement with the subject matter.

Academic growth in an AI mediated learning environment calls for the development of other skills alongside traditional academic skills. AI mediated learning environments create a need for students to learn how to critically analyze data, distinguish between legitimate and illegitimate AI outputs, exercise rational judgment, articulate knowledge learned in the classroom to everyday situations, and develop skills that are professionally and personally relevant. One of the more important and less researched skills is financial awareness. In an AI mediated learning environment, students deal with a variety of financial issues that include budgeting, saving, borrowing, online financial transactions, cash flow, and funding the various costs associated with education that include part time jobs. Financial awareness is an integral aspect of a student's development because traditionally acquired academic skills do not guarantee that a student will make prudent financial decisions. There is an increasing focus on financial literacy in Pakistani universities. Prudential decisions have the potential to negatively affect individuals even after students have completed their education. AI mediated learning environments have the potential to provide personalized explanations of financial concepts, create hypothetical financial scenarios, and allow students to compare various alternatives. This potential needs to be researched because financial information produced by AI can be incomplete and inaccurate. Creating responsible learning environments also requires the ability of students to critically evaluate financial information generated by AI.

Research Gap and Rationale of the Present Study

While the literature of AI in education is growing, the majority of previously published research focuses on academic achievement, learning, motivational and engagement constructs and adopted technology, while other intersections of AI-augmented cognition, financial awareness, engagement, and learning, and students' development in other areas is neglected. Recently published systematic reviews show that while GenAI could potentially increase both academic performance and engagement, significant contextual variability and reliance on AI could be dangerous (Hon, et al., 2026). As said, GenAI might support the development of cognitive, technical, and interpersonal skills (Daniel, et al., 2025). However, integrated empirical research that studies AI-augmented cognition in an educational context is still lacking. The research on GenAI and financial awareness, as well as engagement in learning, and students' development in other areas of education, is urgently needed, especially in higher education. Students need to be able to independently engage in learning and develop responsibility and critical thinking when using new platforms. For these reasons, this study will analyze the AI-cognitive scaffolding theories and financial awareness, learning engagement and development in other areas of education. This study intends to fill the research gap and provide some literature on this important topic. An integrated perspective can be useful in evaluating the scope of AI's function beyond being a substitute for academic labor within contemporary higher education. It can also assess the extent to which intentional deployment of AI impacts student development beyond academia.

Research Objectives

- To examine the relationship between AI-augmented cognition and financial awareness among university students.
- To determine the association between AI-augmented cognition and students' learning engagement.
- To assess the influence of AI-augmented cognition on students' academic development.

Research Questions

- What is the relationship between AI-augmented cognition and financial awareness among university students?
- What is the relationship between AI-augmented cognition and students' learning engagement?
- To what extent does AI-augmented cognition influence students' academic development?

Problem Statement

Integration of generative AI into higher education provides students an opportunity to access personalized academic support and develop their cognitive and academic skills. However, there are also educational implications that come with the use of AI that are complex and are still relatively unknown. The available systematic research shows that learning outcomes and higher order thinking are improved in the presence of GenAI. These gains, however, are context-specific and depend on the design of teaching activities, duration of use, and the way students interact with AI (Chen & Cheung, 2025; Han et al., 2025). At present, it is well-documented that the use of AI lowers self-directed effort and critical evaluation of AI output (Liu & Zhong, 2025). It should also be noted that the use of AI does not promote academic development as it is intended to. Research explores the use of AI and learning engagement in the context of academic achievement. There is, however, a glaring gap in the understanding of AI-augmented cognition as an educational process that supports a student's academic development, their financial awareness, and learning engagements. Financial awareness, in particular, is under researched in the context of AI and higher education and should be of more concern, because of the growing digital economy and its impact on the financial decisions students are required to make. This gap is significant in lower-income countries like Pakistan where one of the latest studies show university students have only moderate AI literacy. Furthermore, researchers work to develop university students' ability to understand, evaluate, and ethically use AI (Digital Library Perspectives, 2026). The problem is not just students using AI, it is about the impact of AI-enhanced cognitive engagement on student development. The answer to this gap will be to do a new empirical study on the relationship between AI-enhanced cognition, financial understanding, learning engagement, and academic development. This will demonstrate to educators how AI can be used as a cognitive and developmental tool rather than an easy digital substitute.

Significance of the Study

Limiting AI's role to the completion of academic tasks fails to appreciate the extent to which AI-augmented cognition may support students' educational progress and development. This study, therefore, provides an opportunity to fill this gap by exploring the relationship that AI-augmented-cognitive systems may have with financial awareness, learning engagement, and development in the formative years of an academic career. Xia et al. (2025) report that when used appropriately, generative AI may have positive effects on students' learning, engagement, and motivation. The integration of AI into learning settings, however, influences the extent to which the technology may be useful. Therefore, this study is significant to educational practitioners and institutions of higher education, as it is likely to provide much-needed evidence to support the development of AI-based systems that may be used to enhance students' active engagement and critical thinking during learning, and development of the student as an academic, rather than relying on automated response systems. Furthermore, large-scale research analyses indicate that GenAI's effects on student engagement may be mediated by the level of challenge and instructive support provided by the educator (Guo et al., 2025). This study is also likely to be the first to incorporate financial awareness into the field of AI in education and therefore is likely to create constructive bridge between technology and the Cognitive domain that may influence students' financial awareness during the formative years of their academic careers. Finally, it is likely to influence the way educators, policy-makers, and institutions of higher learning respond to the challenges of AI literacy and its impact on breadth of student competencies beyond academics and on informed decision-making.

Literature Review

Students need to understand how to manage their personal finances now more than ever. Budgeting, savings, investing, and cash management are all financial decisions that students must learn to navigate. Some students and adults also lack the financial literacy needed to evaluate financial information, recognize financial risks, and evaluate options. Financial decisions are often based upon financial knowledge. In the case of AI-driven learning, students could have access to technology that explains answers and financial information in real time. Technology could create examples and walk users through scenario-based learning and inform them about the different courses of action. Financial Education in the Age of Artificial Intelligence, 2026) is an example of recent research that supports the integration of AI and financial education. It focuses on a systematic review of the recent emphasis in financial education on artificial intelligence and the use of machine learning and generative AI to smart systems. The literature indicates that ethical and responsible use of AI is a priority, and is a growing concern. Finally, AI-based learning has the potential to assist students with cognitive learning and provide methods to articulate and connect abstract financial concepts to contextual examples.

The integration of generative AI technologies with the understanding of cognitive financial structures is significant for multiple reasons. Generative AI models can provide personalized explanations while adaptively responding to a learner's ever-evolving financial knowledge. AI systems, as opposed to delivering the same financial information to all learners, can respond to queries, control terminological complexity, provide examples, provide alternative financial choices, and carry out different scenarios. As stated by Timmerman (2026), a participant group that was provided with ChatGPT-based materials on budgeting, debt, and investment reported better self-assessed financial knowledge. However, it was noted that the levels of improvement differed greatly with higher initial financial literacy reporting larger incremental improvements. This study provides a critical foundation for AI-based cognitive enhancements. The authors note that AI most likely supports cognitive processes in students and, as a result, strengthens prior knowledge. Likewise, Bernatska et al. (2025) indicated that certain AI-based apps, when used to guide financial management and financial literacy, enable users to manage their finances in a more effective manner by aligning financial information to the user's personal finances. Thus, the process of financial cognitive enhancements most likely occurs progressively through a series of interactions.

Empirical research shows that AI in financial learning can also impact the cognitive processes involved in financial decision-making, in addition to financial knowledge. Bayly-Castaneda and Ramírez-Montoya (2025) researched a personalized AI agent for an undergraduate personal finance course regarding critical thinking and decision-making and financial behavior. Bayly-Castaneda and Ramírez-Montoya's work is significant as it shows that AI can go beyond serving as an information provider and can create an environment for financial learning that supports higher-order thinking. More recent work also supports this idea. Using a classroom-based experiment with 134 participants, Santos et al. (2026) reported that a GenAI-based financial learning environment created better financial outcomes and more strategic spending compared to the control group, and also improved financial knowledge. However, they found an AI-related cognitive load paradox and showed that AI helps reduce the cognitive effort to grasp complexity, although it creates other cognitive loads. AI reliably facilitates financial awareness when it is embedded in purposeful

learning activities that require students to think, compare, reflect, decide, and act, instead of blindly following AI-based recommendations.

AI-Augmented Cognition and Learning Engagement

Learning engagement measures a student's participation and connection to their learning. Dimensions of learning engagement in higher education include the behavioral, emotional, cognitive, and increasingly the agentic. AI-enhanced cognition is changing the landscape of learning engagement. AI systems can provide students with feedback, explanations, and opportunities for engagement in a more interactive and adaptive way. AI systems can present students with an opportunity to explore information based on their specific needs. Faisal, E. (2026) conducted a systematic review and meta-analysis of GenAI interventions. It found positive effects of GenAI interventions on university students' motivation and multiple forms of engagement, which include the cognitive, behavioral, and emotional aspects. The authors found that the effects were moderated by the context and the learning strategies used in combination with the subject taught. The authors concluded that GenAI does not automatically drive engagement. Rather, it is more effective as a tool if it is integrated within appropriate pedagogy.

When it comes to AI-augment cognition, the cognitive dimension of engagement pertains to students' psychological involvement towards understanding, analyzing, associating, and applying knowledge. Considering AI tools, cognitive engagement may occur while a student poses repetitive questions to a tool for explanation and clarification. Engagement may also occur while a student checks their understanding, or while a student interacts with a tool to evaluate multiple solutions for a given problem from different angles. According to Heung and Chiu (2025), in their systematic review and meta-analysis of 17 empirical studies and 1735 participants, ChatGPT-based learning resulted in a medium effect size for overall student engagement with a greater emphasis on cognitive engagement. The authors noted that personalized tutoring, technical assistance, content development, and collaboration were the primary mechanisms of engagement supported by ChatGPT. Deng et al. (2025) in their systematic review and meta-analysis of experimental learning studies, also noted that ChatGPT may support learning by positively influencing both students' readiness to engage and the cognitive depth of their engagement. It may be concluded that AI-augmented cognition primes students to actively engage with learning materials instead of passively receiving knowledge.

The relationship between AI and learning engagement is not always optimistic. AI-assisted learning systems can get students to engage by getting students to participate and providing instant answers. Reliance on AI systems can, however, lead students to be passive when it comes to thinking for themselves. Lo et al (2024), in a review of 72 empirical studies, identified both positive and negative outcomes of learning aided by ChatGPT. While the outcomes of participating and certain positive emotional and cognitive states were noted in the literature, the authors cited a host of negative outcomes, such as diminished critical thinking, increased reliance and cheating, and a lack of evidence concerning deep cognitive involvement such as self-regulation. Riva, G (2026) noted that, unlike the case with a reliance on technology, GenAIs should be integrated into learning with a strong foundation of pedagogy. Their review revealed that learning with GenAI required purposeful pedagogy because the effects of AI on learning were dependent on the design of the research, the teaching approaches, and the way AI was integrated into learning. AI-augmented cognition should be an active process in which students engage in critical questioning and reflection and use AI to construct their own knowledge.

AI-Augmented Cognition and Students' Academic Development

The dimension of student-centered academic growth in higher education now covers a lot more than just traditional assessment of grades or performance on summative examinations. It encompasses the components of self-regulated learning, the acquisition of higher-order thinking skills, and the ability to apply academic knowledge to real-life situations, among others. In that context, AI-based systems offer learners the opportunity to access extra resources to aid the application of academic knowledge. Some Generative AI technologies have the capability to answer questions, offer prompts, and generate feedback, alternatives, and examples to scaffold engagement with academic materials. GenAI has also been researched by Ilyas, S et al., (2025) and published in a systematic review and meta-analysis of 57 studies. The researchers reported a positive influence of GenAI on a variety of university-based learning outcomes including the acquisition of skills in higher-order thinking, academic performance, and language proficiency. The research revealed that the positive influence of GenAI extends beyond the completion of individual tasks and supports a variety of dimensions of student-centered academic growth, or cognitive skills.

In the context of student-centered academic growth, AI has the potential to aid the development of higher-order cognitive skills. Beyond traditional academic growing, which requires students to learn how to analyze, explore, and evaluate evidence in order to

construct arguments and cultivate the ability to undertake independent and original thinking, advanced AI technologies and systems can be used as cognitive partners to engage in discussions and challenge assumptions while providing students of all skill levels with instant feedback. Recent empirical studies support this view. According to Tian and Zheng (2025) in their meta-analysis, AI was seen to enhance critical thinking, communication, collaboration, and creativity skills of students to some extent. It was observed that adaptive and personalized learning systems enhanced AI's effects. There is more recent evidence in a systematized review of 67 empirical studies in the 2026 literature, which suggests that ChatGPT fosters both critical and creative thinking within inquiry-based instructional scaffolds, provided that students are actively engaged in reasoning, reflection, and idea generation and evaluation. Thus, AI augmented-cognition may support academic development in the sense that students use AI to supplement their thinking, rather than electronic brain substitutes.

An additional dimension is students' academic achievement and learning outcomes. AI-assisted learning may help students identify weaknesses, clarify concepts, perform academic skills, and receive instructional feedback. This may aid students in higher education the most, where learners may differ in prior knowledge, speed of learning, and academic support. Fallah, D et al., (2025) in one of the few reviews that analyze the use of GenAI on learning, reviewed and analyzed 68 studies. They reported a positive effect of GenAI-assistance on learning outcomes, and reported that the effects varied on the level of education, the domain of instruction, the length of the intervention, the traits of the sample, and the context of instruction. Matthew, U et al., (2026), stated that participants showed positive effects on academic achievement and higher-order thinking, and no significant effects on metacognition. This shows the variances between the two, as improving learning may not always include developing cognitive independence. This study focuses on academic development, and not solely achieving better grades. Students should have the ability to regulate learning and apply their knowledge with less reliance on technology, such as with the aid of AI technology.

Research Gap

Although the study of AI in higher education is rapidly increasing, visible gaps remain when addressing how AI-augmented cognition impacts students in the context of their wider educational development. Most studies cover the generative AI domain in relation to achievement in academics and learning, motivation, engagement, and an advanced level of thinking. Park, J (2025), for example, indicated that GenAI has positively impacted academic achievement and higher-level thinking. Meanwhile, Chaudhry, M et al., (2024) reported positive impacts of GenAI-based interventions on outcomes related to learning in different educational contexts. Likewise, Tariq, M (2024) indicated that the use of ChatGPT in learning had positive impacts on the cognitive engagement of students. Overall, these studies tend to view AI within learning difficulties or as a learning tool, rather than AI-augmented cognition as a process of cognitive integration that expands students' abilities to think, make decisions, and learn. The studies in this area have also overlooked financial awareness in a critical way, even though financial knowledge and personal capital management are essential to university students within an informed framework. The existing studies on AI and financial education have predominately employed the use of financial literacy and financial decision-making, financial management, and AI-based tools. AI's role in financial awareness, and cognitive integration and development in education, has been neglected in these studies. While some systematic reviews have documented apprehensions about excessive dependence on AI, cognitive offloading, diminished critical reasoning, and the need for constructive pedagogical frameworks (Kim, J, et al., 2022), academia generally lacks a unified, empirical perspective on how, or if, AI-augmented cognition interfaces or integrates with financial acumen, learning engagement, and students' academic progress. Such a study would benefit research on the educational implications of AI in postsecondary education, as it would shift the focus from whether students employ AI to whether students' cognitive AI use facilitates academic and professional progress beyond the purely academic context.

Research Hypotheses

- **H1:** There is a significant positive relationship between AI-augmented cognition and financial awareness, learning engagement, and students' academic development among university students.
- **H2:** AI-augmented cognition significantly predicts financial awareness, learning engagement, and students' academic development among university students.
- **H3:** There is a significant difference in AI-augmented cognition, financial awareness, learning engagement, and academic development between the two groups of university students based on their AI-use status or another relevant two-category demographic characteristic.

- **H4:** There are significant differences in AI-augmented cognition, financial awareness, learning engagement, and students' academic development across university students belonging to different levels of AI-use frequency.

Methodology

Research Design

A quantitative, cross-sectional research design was developed to analyze the relationships between AI-augmented cognition, financial awareness, learning engagement, and academic progress of students. The primary data-collection tool was a self-administered, structured questionnaire. The study was quantitative, as the variables were measured on a Likert scale. The study was conducted on a population of students at one time point. It was therefore possible to analyze associations and predictive relationships, and also to differentiate different student groups related to the study. The research design was appropriate for obtaining relatively large standardized responses, and also for applying statistical places and carrying out inferential statistical analysis to evaluate the relationships among the study variables.

Population of the Study

Participants of the study were the university students of higher education in Punjab and Sindh, Pakistan. The study population included students of public and private universities and institutions in the major educational regions of the two provinces. Participants in Punjab were selected from the universities and academies in Multan, Lahore, Faisalabad, Bahawalpur, and Sahiwal, whereas in Sindh, participants were selected from universities and academies from Karachi, Hyderabad, Sukkur, and Jamshoro. The study included the universities and other higher education institutes such as Bahauddin Zakariya University, Multan; The Women University Multan; COMSATS University Islamabad, Multan Campus; University of Education, Multan Campus; Government College University Faisalabad; University of the Punjab, Lahore; University of Lahore; Islamia University Bahawalpur; University of Sahiwal; University of Karachi; University of Sindh, Jamshoro; Mehran University of Engineering and Technology, Jamshoro; Shah Abdul Latif University, Khairpur; and other recognized higher education institutes in Punjab and Sindh. The study provided representation to students of various localities of higher education institutions.

Target Audience

The target audience included students of the postgraduate and undergraduate levels in both Punjab and Sindh, Pakistan. The study included students from various disciplines in order to understand the experiences of students comprising social and economic backgrounds with finance and learning, and to capture the development of students' academic skills. The participants comprised students of varied levels of education, who used digital technology and the World Wide Web, and were able to understand, and complete the given online questionnaire. The focus of the study was the students' experiences with AI-supported cognitive tools in their advanced education.

Sampling Technique

A non-probability convenience sampling technique was employed for participant recruitment. As participants were students, they were approached through available university networks and online means of communication. The questionnaire link was shared with participants through the university network and student network, as well as, online, academic groups and through direct communication. To the extent possible, responses were sought from students in different institutions, at different levels of study and from different demographics and disciplines. Participation was voluntary. Respondents were only included if they satisfied the inclusion criteria and provided informed consent.

Sample Size

A total of 467 university students participated in the study. The final dataset contained 467 complete questionnaires. The sample size was considered adequate to perform the planned descriptive and inferential analyses, including correlation, multiple linear regression, independent-samples t-test, and one-way analysis of variance (ANOVA). The large sample size also enabled examination of the relationships among the principal study variables, and subgroup comparisons, within the given datasets.

Data Collection Procedure

I created a research tool to collect data from participants. It was a structured survey that included measurement tools for AI-augmented cognition, financial awareness, learning engagement, and the development of students' academic skills. Some of the survey questions were adapted from widely used relevant tools. I ensured that the constructs I was measuring were described by the indicators I selected. I carefully reviewed each question and changed the wording of some items to contextualize the item and the survey to the setting of post-secondary education and learning that is supported by artificial intelligence. A five-point Likert scale was used to collect survey responses which included: "strongly disagree," "disagree," "neither agree nor disagree," "agree," and "strongly agree."

The construct of AI-augmented cognition was operationalized by survey questions regarding students' use of AI as a cognitive resource for information processing, idea generation, problem solving, and learning. Items were derived from the growing literature of generative AI-based learning and cognitive augmentation that includes students' cognitive involvement with GenAI and AI-supported higher-order learning (Qian, 2025; Liu & Zhong, 2025).

Financial awareness was assessed using adapted items asking about students' understanding and awareness about financial information, budgeting, saving, making financial decisions, and evaluating financial options. The adapted items were based on existing financial literacy studies and recent studies on AI-based financial education and the emerging literature on AI-based financial learning which addresses financial knowledge, financial decisions, and the management of personalized financial information (Bernatska et al., 2025; Timmerman, 2026). The items were adapted to assess students' overall financial awareness rather than specific investment behavior.

Learning engagement was assessed using items asking about students' cognitive and behavioral involvement, as well as their emotional involvement in learning. The scale was developed using existing student engagement studies and recent systematic reviews on the GenAI-based educational environment. Heung and Chiu (2025) found that learning with the support of ChatGPT increased student cognitive engagement, while Xia et al. (2025) reported positive effects of GenAI on several dimensions of students' motivation and engagement.

Items were used to assess students' academic growth in terms of the development of their academic knowledge and skills, critical thinking and problem-solving skills, and their ability to apply their knowledge. The measurement framework was developed using recent studies that found GenAI-based learning could improve students' academic skills as well as higher-order thinking. Chen and Cheung (2025) reported positive effects of GenAI on university students' academic achievement and higher-order thinking, while Han et al. (2025) found positive effects of GenAI-supported learning on different educational contexts' learning outcomes.

Prior to the primary data collection, the questionnaire was assessed for clarity, relevance, and comprehensiveness. The final questionnaire was converted to a Google Forms survey and was emailed to students at universities in Punjab and Sindh via email and through relevant academic and student networks. Prior to completing the survey, participants were informed about the purpose of the study. Participants filled the survey independently and the responses were automatically logged in Google Forms. Following completion of the survey, all the responses were downloaded and organized in Microsoft Excel for data screening and preparation prior to importing to IBM SPSS Statistics for the analysis.

Ethical Considerations

Throughout the study, ethical integrity was upheld. Participation was voluntary and participants were informed about the study's purpose and a general overview of the study prior to completing the survey. Prior to participation, informed consent was obtained electronically and participants were informed that they had the right to refuse participation, that their academics would be uninvolved, and that their relationship with the institution would remain intact. The survey did not request any unnecessary personal information. The survey information was collected and kept confidential for the purpose of academic and research use only. The survey responses were kept securely and the research dataset was the only access to the data during the research process. Participants were informed that their individual response would not be reported in a personal manner.

Data Analysis

Responses were first converted to Excel from Google Forms. The dataset in Excel was then cleared of incomplete and invalid responses and screened. Once finalized, the dataset was imported into IBM SPSS Statistics for further analysis. Descriptive statistics were applied to both demographic variables and the major study variables. The demographic variables were summarized with their respective frequencies and percentage, while means and standard deviation were applied to the continuous variables.

The internal consistency of the questionnaire was then assessed by calculating Cronbach's alpha. The reliability of the construct was assessed by examining the analysis for the items of each construct. Pearson correlation was then performed to determine the relationship between AI-augmented cognition, financial awareness, learning engagement, and the development of students' academic achievement, along with the direction and strength of the relationship.

Multiple linear regression was also performed to determine the predictor value of AI-augmented cognition to financial awareness with learning engagement and the enhancement of students' academic accomplishments. Assessment of the regression equation involved R , R^2 , the value of the adjusted R^2 along with the overall importance of the regression model and the accompanying regression coefficients and significance level, along with the assumptions of linearity, independence, multicollinearity and the characteristics of the residuals, if necessary, prior to the regression model for interpretation.

An independent-samples t-test was performed to analyze potentially significant discrepancies in levels of AI-augmented cognition, financial awareness, learning engagement, and academic development between two relevant student groups. The classifying factor was based on demographic data or AI usage data, and it was defined as two theoretically relevant distinct categories.

For variables with at least three options, a one way ANOVA was used to analyze data to see if there were any statistically significant differences in the student groups. When a statistically significant omnibus ANOVA was obtained, a Tukey HSD post-hoc was used to determine which pairs of groups were significantly different. Results were considered statistically significant with $p < .05$. Effect sizes were reported to give more context to the results.

Table 1: Demographic Characteristics of the Respondents (N = 467)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	248	53.1
	Female	219	46.9
Age	18–20 years	139	29.8
	21–23 years	181	38.8
	24–26 years	96	20.6
	27 years and above	51	10.9
Province	Punjab	286	61.2
	Sindh	181	38.8
Level of Study	Undergraduate	301	64.5
	Master's	104	22.3
	MPhil/MS	48	10.3
	PhD	14	3.0
Academic Discipline	Social Sciences	108	23.1
	Business and Management	96	20.6
	Computer Science/IT	91	19.5
	Education	72	15.4
	Health Sciences	61	13.1

Demographic Variable	Category	Frequency (n)	Percentage (%)
AI Use Frequency	Engineering	39	8.4
	Rarely	58	12.4
	Occasionally	116	24.8
	Sometimes	143	30.6
	Frequently	104	22.3
	Very frequently	46	9.9
Previous GenAI Experience	Yes	394	84.4
	No	73	15.6
Total Respondents		467	100.0

The demographic data obtained from the 467 participants indicated that there was adequate representation of the main demographic factors covered in the survey. Of the total number of participants, 53.1% were male and 46.9% were female. The sample comprised mainly young university students, with 38.8% of participants in the age range 21–23 years and 29.8% in the age range 18–20 years. 61.2% of participants were from Punjab and 38.8% were from Sindh. Among the participants, 64.5% were undergraduates, 22.3% were Master's students, 10.3% were M. Phil/MS students, and 3.0% were PhD students. The Social Sciences discipline comprised 23.1% of the participants, with the Business/Management and Computer Science/IT disciplines comprising 20.6% and 19.5% of the participants respectively. 30.6% of the participants occasionally used AI, 24.8% used AI Sometimes, and 22.3% used AI frequently. Of the participants, 84.4% had used generative AI tools previously. The results indicate that the participants represented different academic disciplines and different regions. Further, the participants represented varied levels of generative AI use.

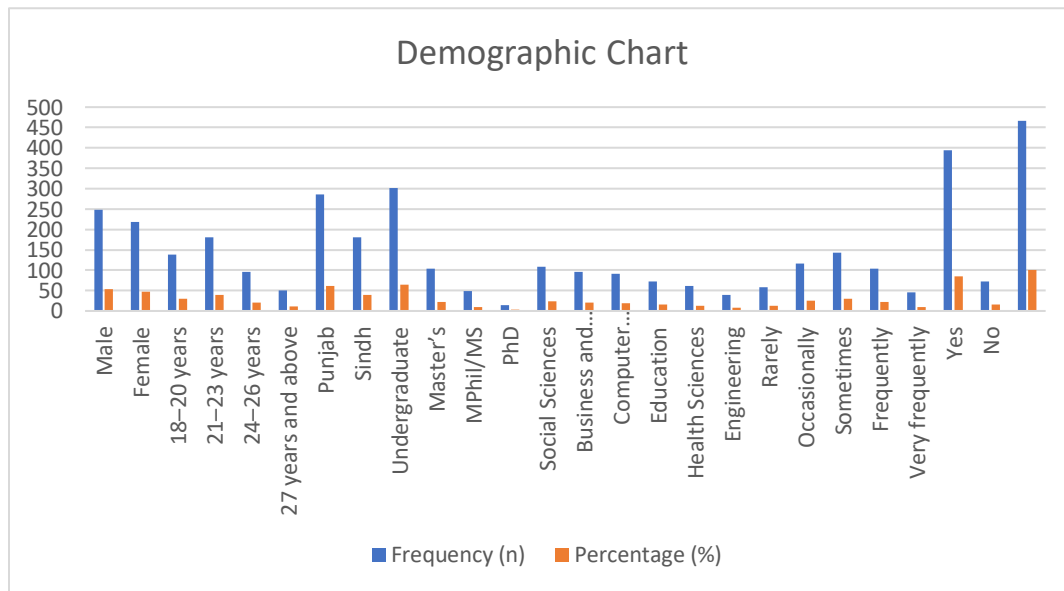


Fig: 1 Demographic Chart

Table 2: Pearson Correlation Analysis of AI-Augmented Cognition, Financial Awareness, Learning Engagement, and Students' Academic Development Among University Students (N = 467)

Variables	1	2	3	4
1. AI-Augmented Cognition	1			

Variables	1	2	3	4
2. Financial Awareness	.542**	1		
3. Learning Engagement	.618**	.574**	1	
4. Students' Academic Development	.671**	.596**	.704**	1

Note. $N = 467$. ** $p < .01$ (two-tailed).

According to the Pearson correlation analysis, all of the major study variables exhibited statistically significant positive relationships. For AI-augmented cognition along with financial awareness, a relationship of moderate positivity was observed, wherein with the increasing levels of AI-augmented cognition, the financial awareness of students was observed to increase. In addition, a positive, stronger relationship of AI-augmented cognition was observed with the learning engagement and academic development of students ($r = .671$, $p < .01$). With respect to financial awareness, a positive relationship was observed with learning engagement ($r = .574$, $p < .01$) and academic development ($r = .596$, $p < .01$). Additionally, a positive relationship was observed with academic development ($r = .704$, $p < .01$). From the preceding point of view, a positive relationship was observed for AI-augmented cognition, financial awareness, learning engagement, and academic development of students.

Table 3: Multiple Linear Regression Analysis of AI-Augmented Cognition Predicting Financial Awareness, Learning Engagement, and Students' Academic Development Among University Students ($N = 467$)

Dependent Variable	Predictor	β	t	p	R	R^2	Adjusted R^2	F
Financial Awareness	AI-Augmented Cognition	.542	13.98	<.001	.542	.294	.292	195.44***
Learning Engagement	AI-Augmented Cognition	.618	16.78	<.001	.618	.382	.381	281.54***
Academic Development	AI-Augmented Cognition	.671	19.60	<.001	.671	.450	.449	384.16***

Note. $N = 467$. β = standardized regression coefficient; R^2 = coefficient of determination; *** $p < .001$.

The multiple regression analysis showed that AI-augmented cognition predicted all aspects of students' growth. Financially, AI-augmented cognition predicted students' financial awareness with a beta of .542, and a total effect size of 29.4% ($R^2 = .294$). Similar results were found for learning engagement, for which AI-augmented cognition predicted a total effect size of 38.2% ($R^2 = .382$) and a beta of .618. Students' academic growth showed the strongest prediction with a total effect size of 45.0% ($R^2 = .450$) and a positive beta of .671. The positive relationship was overall statistically significant (F-statistics), indicating that a higher level of AI-augmented cognition led to university students' improved financial awareness, enhanced learning engagement, and higher levels of academic growth.

Table 4: Independent-Samples t-Test of Differences in AI-Augmented Cognition, Financial Awareness, Learning Engagement, and Students' Academic Development by Previous Generative AI Experience ($N = 467$)

Variable	GenAI Experience	n	Mean	SD	t	p
AI-Augmented Cognition	Yes	394	3.82	0.61	5.72	<.001
	No	73	3.43	0.57		
Financial Awareness	Yes	394	3.76	0.64	4.38	<.001
	No	73	3.39	0.63		
Learning Engagement	Yes	394	3.84	0.59	5.11	<.001
	No	73	3.49	0.55		
Students' Academic Development	Yes	394	3.88	0.58	5.86	<.001
	No	73	3.47	0.62		

Note. $N = 467$. SD = standard deviation. $p < .05$.

The independent-samples t-test revealed significant differences between the two groups, both with and without previous experience with generative AI, in all key study variables. Regarding AI-augmented cognition, students with previous experience with generative AI reported higher levels than students without ($M = 3.82$, $SD = 0.61$ and $M = 3.43$, $SD = 0.57$, respectively), $t = 5.72$, $p < .001$. Similar results were observed with financial awareness ($M = 3.76$, $SD = 0.64$ and $M = 3.39$, $SD = 0.63$, respectively), $t = 4.38$, $p < .001$. Again, previous experience with GenAI demonstrated higher levels of learning engagement, ($M = 3.84$, $SD = 0.59$ and $M = 3.49$, $SD = 0.55$, respectively), $t = 5.11$, $p < .001$. Lastly, students with reported experience with generative AI demonstrated more development in academic ($M = 3.88$, $SD = 0.58$) and students without experience reported less development in academic ($M = 3.47$, $SD = 0.62$), $t = 5.86$, $p < .001$. It can therefore be concluded that previous exposure to generative AI positively affected AI-augmented cognition, financial awareness, learning engagement, and academic development.

Table 5: One-Way ANOVA of AI-Augmented Cognition, Financial Awareness, Learning Engagement, and Students' Academic Development Across Different AI-Use Frequency Groups ($N = 467$)

Dependent Variable	F	df Between	df Within	p	η^2
AI-Augmented Cognition	12.84	4	462	<.001	.100
Financial Awareness	8.67	4	462	<.001	.070
Learning Engagement	10.92	4	462	<.001	.086
Students' Academic Development	14.76	4	462	<.001	.113

Note. $N = 467$; η^2 = eta-squared effect size; $p < .05$.

Tukey HSD Post-Hoc Comparisons

Dependent Variable	Significant Group Comparisons	Mean Difference	p
AI-Augmented Cognition	Rarely vs. Frequently	-0.42	<.001
	Rarely vs. Very frequently	-0.57	<.001
	Occasionally vs. Very frequently	-0.39	.002
Financial Awareness	Rarely vs. Frequently	-0.34	.006
	Rarely vs. Very frequently	-0.48	<.001
	Occasionally vs. Very frequently	-0.31	.018
Learning Engagement	Rarely vs. Frequently	-0.38	.001
	Rarely vs. Very frequently	-0.52	<.001
	Occasionally vs. Very frequently	-0.36	.004
Students' Academic Development	Rarely vs. Frequently	-0.46	<.001
	Rarely vs. Very frequently	-0.61	<.001
	Occasionally vs. Very frequently	-0.40	.001

A one-way ANOVA found statistically significant differences across all four study variables in students from different groups of AI use frequency. Statistically significant results were seen in AI-augmented cognition, $F(4, 462) = 12.84$, $p < .001$, $\eta^2 = .100$; financial awareness, $F(4, 462) = 8.67$, $p < .001$, $\eta^2 = .070$; learning engagement, $F(4, 462) = 10.92$, $p < .001$, $\eta^2 = .086$; and students' academic development, $F(4, 462) = 14.76$, $p < .001$, $\eta^2 = .113$. Small to moderate differences were indicated in these effect sizes. The Tukey HSD post-hoc analysis suggested that students from the different groups of AI use frequency showed significant differences in AI-augmented cognition, financial awareness, learning engagement, and academic development. The largest group differences were seen in students' academic development. This indicated the use of AI was associated primarily with students' perceived academic development. The other outcomes were also significantly differentiated in students' AI use.

Discussion

Some students struggle to adjust to the world of higher education. They can become overwhelmed and confused. There isn't enough guidance to explain things, and the students lack the skills to answer the questions necessary to clarify confusing concepts. However, digital technology, especially AI, has a ton of positive potential outcomes in the educational field, and the findings of this study corroborate this outcome. The data shows that students that are more actively using AI as a cognitive tool report a positive attitude towards their studies, academic development, and the financial world. This finding endorses other evidence that indicates that generative AI positively supports students' learning outcomes in universities. The context and integration of AI into the curriculum impact the extent of the outcome. (Raman, R, et al., 2026).

The finding can be explained because many students struggle to understand financial information. This issue can be tackled by the use of generative AI. Financial related tasks can be made simpler. AI based systems can help students interpret and answer financial related questions, and offer financial related definitions and explain complex financial terminology in easy to understand language. Even though there are other frameworks that focus on specific users, AI and financial awareness, this study adds depth and breadth to the field of AI and education. The use of AI can offer students the tools needed to develop and apply competencies that assist them outside of the academic world. While the creation of AI-generated financial data may prove useful, such data will typically include errors. Therefore, it remains necessary to critically evaluate and verify this data.

There was a large correlation between AI-augmented cognition and learning engagement, $r = .618$ ($p < .01$). This is further supported by Al-Chaer, E (2024) who integrated 17 empirical studies with 1,735 students and found that learning integration with ChatGPT represented a medium positive effect on overall student engagement, particularly on cognitive engagement. Engagement through ChatGPT was attributed to personalized tutoring and technical assistance, content production, and collaboration engaged through the solution. Based on this finding, AI has a strong positive effect on learning interaction and responsiveness by offering feedback and providing academic assistance on an individual basis. However, the studies noted that excessive reliance on AI would lead to disengagement and a decline in critical thinking, thus, the quality of AI-assisted engagement is important, rather than the number of interactions.

The highest correlation in this study was between AI-augmented cognition and student academic development, $r = .671$ ($p < .01$), and regression analysis showed that AI-augmented cognition predicted academic development ($\beta = .671$, $p < .001$), accounting for 45.0% of its variance. This is in line with Mutambik, I (2024), meta-analysis, which reported GenAI positively influenced university students' learning achievements and higher-order thinking. Their synthesis showed a medium positive effect on higher-order thinking and a positive effect on learning achievements, but the overall effect on metacognition was not significant. Bhattacharjee, A et al. synthesized 29 experimental and quasi-experimental studies, and found a moderate positive effect of GenAI on higher order thinking, especially on problem solving and critical thinking. Thus, the results of this study add further evidence that AI can serve as a layer within the cognitive scaffolds to assist students in information-processing, idea generation, problem solving and development of academic skills.

The group-comparison results confirm these interpretations. Students who have used generative AI before exhibited higher levels of AI-augmented cognition, financial awareness, learning engagement, and academic development, when compared to students who had no prior experience with generative AI. The ANOVA also showed significant results regarding AI use frequency. Students who reported AI usage most frequently and very frequently were more likely to exhibit the variables of interest. This supports recent work showing varying educational effects of GenAI, based on students' interaction with AI in conjunction with the instructional context and the strategy that students employ. In their work, Mokhtar et al. (2024) noted GenAI's positive effects on students' motivation and engagement; however, they noted that the effects were dependent on learning strategy and the instructional context. In a similar study, GenAI's positive effects in the area of higher order thinking were more pronounced on students with higher self-regulated learning.

Conclusion

The study has demonstrated AI-augmented cognition as an important emerging factor in contemporary higher education, and as a positive contributor to students' financial awareness, learning engagement, and academic development. All significant positive relationships were demonstrated between AI-augmented cognition and financial awareness, learning engagement, and academic development, while the regression analysis demonstrated AI-augmented cognition as a positive and significant predictor of all

outcomes. Furthermore, the students who had generative AI experience reported higher levels of the study variables, and significant results were demonstrated at different levels of AI-use frequency. These results show that students use private tutoring to access information, articulate ideas, clarify understanding, and resolve various problems within the learning process. The results also show that AI tutoring systems can stimulate learning and promote educational growth on a larger scale.

The study concludes that the educational impact of AI is not defined by the number of times AI is used or if AI is readily accessible. It is determined by the cognitive effort that students invest into the technologies. Therefore, AI should be treated as a cognitive framework aid that students can use to reinforce their reasoning and reflection, as well as to evaluate, self-regulate, and sustain their learning. The results of the study are positive and support the conclusion of the study. Given the nature of the study is cross-sectional, concluding an actual cause is not possible. The study supports the current literature and shows that AI enhancing cognition may have implications well beyond the traditional classroom and academic situation. This may include the development of the student as a financially responsible citizen. It may also include the development of sustained, persistent learning engagement.

Recommendations

1. Integrate AI literacy into higher education curricula to help students use AI critically, effectively, and responsibly.
2. Promote AI-supported active learning by encouraging students to use AI for explanation, problem-solving, brainstorming, and knowledge exploration rather than simply generating assignments.
3. Strengthen financial education by incorporating AI-supported financial awareness activities, including budgeting, saving, financial planning, and evaluation of financial information.
4. Develop students' critical thinking skills so they can verify AI-generated information, identify inaccuracies, evaluate evidence, and make independent academic judgments.
5. Provide faculty training on AI integration to enable instructors to design learning activities that use AI as cognitive support while maintaining meaningful student participation.
6. Establish responsible AI-use guidelines within universities covering academic integrity, privacy, appropriate AI dependence, information verification, and ethical use.
7. Conduct longitudinal and experimental research to determine the long-term effects of AI-augmented cognition on financial awareness, learning engagement, academic development, and students' independent learning capabilities.

Future Implications

The findings of the present study predict implications on the future of AI-infused higher education with the integration of artificial intelligence in students' academic and daily choices. Future technology may innovate beyond viewing AI as a tool for information retrieval or assistance in the completion of assignments. They may progress towards visualizing AI as a tool for cognitive support for critical thinking and problem solving, personalized learning, financial understanding, and the development of scholarly achievements. Consequently, universities may shift focus and revise their curricula to incorporate AI literacy, responsible AI use, and financial literacy, as well as driving higher-level learning, while faculty may require additional instruction to develop activities that enable students to think critically and express themselves instead of relying on the prompts provided by AI. Longitudinal and experimental research designs across various countries, educational disciplines, and institutional frameworks should examine these relations and consider possible mediating and interaction factors, such as self-regulated learning, AI literacy, digital competence, critical thinking, and the attitudes of individuals to AI. This may clarify to what extent AI's role in cognitive enhancement of users may lead to lasting advances in the scholarly and practical development of individuals, and to what extent it facilitates short-term learning.

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