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AI-Assisted Education and Students' Metacognitive Awareness: Examining the Role of Cognitive Flexibility and Self-Regulated Learning

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ABSTRACT

This study examined the influence of AI-assisted education on students' metacognitive awareness, focusing on the roles of cognitive flexibility and self-regulated learning. A quantitative, cross-sectional research design was adopted, and primary data were collected through a self-administered questionnaire distributed via Google Forms among 347 university students enrolled in public and private higher education institutions across Pakistan, including the University of the Punjab, Bahauddin Zakariya University, Government College University Faisalabad, International Islamic University Islamabad, University of Karachi, University of Peshawar, and the University of Balochistan. Convenience sampling was employed to recruit students familiar with AI-assisted educational tools. The collected data were analyzed using SPSS through descriptive statistics, reliability analysis, Pearson correlation, and simple linear regression. The proposed reliability analysis demonstrated satisfactory internal consistency, with Cronbach's alpha values ranging from 0.843 to 0.892 across the study constructs. Regression results indicated that AI-assisted education positively predicted students' metacognitive awareness ($\beta = 0.694$, $R^2 = 0.482$, $p < 0.001$) and cognitive flexibility ($\beta = 0.781$, $R^2 = 0.610$, $p < 0.001$). Similarly, self-regulated learning positively predicted metacognitive awareness ($\beta = 0.765$, $R^2 = 0.585$, $p < 0.001$). These findings suggest that AI-assisted educational practices can support students' awareness of their learning processes, adaptability in academic situations, and ability to regulate their learning independently. The study is significant because it provides insights into the educational and psychological implications of AI integration in Pakistani higher education and highlights the importance of combining technological support with students' cognitive and self-regulatory abilities. It further emphasizes that AI tools should complement rather than replace independent thinking, critical reflection, and active student participation. The findings may guide educators and policymakers in developing responsible, student-centered, and technology-supported learning environments that strengthen metacognitive development and improve the quality of higher education.

Introduction

AI-Assisted Education and Students' Metacognitive Awareness

In today's education system, Artificial Intelligence (AI) is becoming an important tool for supporting students in their learning activities. It provides students with new ways to find information, understand different topics, and improve their learning experiences. AI-assisted education refers to the use of AI-based tools and platforms, such as ChatGPT, Gemini, intelligent learning systems, and personalized learning applications, to help students understand difficult concepts, access learning materials, and complete their academic tasks more easily. These technologies give instant feedback, individual explanations and educational suggestions based on students' learning needs. Based on their conclusions, Holmes (2019) suggest that AI can revolutionize the whole educational landscape by aiding in personalized learning and enhancing teaching methods. Likewise, Zawacki-Richter et al. (2022) argued that AI can be used to support students, assess students, and create adaptive learning environment. As generative AI becomes more prevalent, students will also have greater opportunities to engage with digital learning materials and get instant academic support (Ji & Tan, 2026).

Another key concept in educational psychology is metacognitive awareness, which refers to an understanding of thinking and learning processes that students use to understand, monitor and control their thinking and learning. It is a person's self-knowledge regarding knowledge, learning skills, strengths, and weaknesses as well as the use of appropriate strategies to complete academic tasks. Mazari (2025) have described the metacognitive awareness as having two broad dimensions: metacognitive knowledge and metacognitive regulation. Knowledge of cognition is about understanding cognitive learning processes; regulation of cognition is about planning, monitoring and evaluating cognitive activities of learning. In a similar way, Akram et al., (2025) pointed out the importance of the metacognition process in which one is aware of one's own thinking process and controls it. These skills are used to identify learning challenges, assess learning and make appropriate adjustments to promote learning success.

AI supported learning can help develop students' metacognitive skills by allowing them to revisit the content, learn what they don't know, explore different interpretations, and consider their learning. AI can help students ask questions, compare answers, and analyze explanations, potentially raising students' awareness of their learning development and limitations. But it's not just about accepting answers that are generated by AI, it's about students using the technology. AI-assisted learning can have a positive impact on metacognitive awareness and regulation, but the results vary based on how students interact with AI.While the impact may differ, AI-supported learning can positively impact metacognitive awareness and regulation, depending on the nature of student-AI interaction, according to Tezer (2025). Likewise, Wiedbusch and Azevedo (2023) explained the need to monitor and control cognitive activities in learning. Thus, AI-enhanced learning can enhance students' metacognitive awareness if students learn with AI as an aid to learning and do not rely on AI for their thinking.

Cognitive Flexibility and Its Relationship with AI-Assisted Education and Metacognitive Awareness

Cognitive flexibility is the ability to change thinking patterns, take on different viewpoints and alter strategies as situations and learning needs change. It is a key cognitive skill which helps students think around academic issues, comprehend complex information and react to new issues. Mughal et al., (2026) defined cognitive flexibility as the awareness of other options, willingness to adapt and confidence that change is possible. Shukla (2026) also stated that cognitive flexibility is the capacity to think flexibly and offer alternate explanations when challenged by difficult situations. In schools, students who are cognitively flexible may think through several solutions and review various sources of information and adjust their learning strategies as needed based on the educational demands.

AI-powered learning can offer opportunities for students to learn about the flexibility of thinking by presenting them with alternative explanations, viewpoints, and problem-solving methods. AI-powered educational tools give students the freedom to experiment with other ideas, ask additional questions, compare information, and tackle academic ideas in various ways. These learning experiences can help students shift away from a traditional way of thinking and become more flexible in tackling more challenging academic assignments. Romdhoni et al. (2025) pointed out the promise of AI technologies for adaptive and personalized education. In addition, Davor et al., (2026) concluded that two important applications of AI in higher education are personalized learning and intelligent tutoring. These learning opportunities can promote the study of information from various angles and flexible learning and problem-solving strategies.

Cognitive flexibility also can help students be metacognitive because flexible thinkers more readily will be able to identify when they are using a learning strategy that isn't working and when they need to try something new. Students will be better able to notice their strengths and limitations cognitively if they are able to think differently about their assumptions, look at multiple explanations, and alter their thinking (Aurangzeb & Uddin, 2025). This skill can help students monitor their learning and motivate them to check

their learning before they consider it as accurate. Likewise, Simo et al. (2026) suggested that cognitive flexibility plays a special role in the case of learning complex and unfamiliar knowledge from many points of view. In this context, cognitive flexibility could be a major factor in helping to enhance the connection between AI-based education and students' metacognition.

Self-Regulated Learning and Its Relationship with AI-Assisted Education and Metacognitive Awareness

Self-regulated learning is an active management of learning in which learners set learning targets, choose learning strategies, monitor their learning progress and assess their learning results. It encourages students to actively participate in their own learning process and not solely rely on their teachers or other learning materials. In the view of Dahri et al., (2024), SRL is the active role played by the learner in the learning process, both in cognitive, motivational and behavioral aspects with the aim of achieving learning goals. In the same way, Chen et al., (2024) viewed SRL as an active process that involves self-staging of learning goals and self-controlling of cognition, motivation and behavior to meet academic demands. Plan, monitor and reflect are other crucial factors Ayaz et al., (2026) emphasized in various models of SRL. The processes are designed to enable the students to learn through self-directed learning and develop self-academic management skills.

AI-driven learning could aid in fostering SRL through tailored feedback, tailored learning recommendations, and immediate access to learning information. Students can use AI-powered platforms to identify their learning needs, plan their learning activities, summarise challenging concepts and assess their performance. These features can help draw students to assume greater responsibility for their learning and make learning decisions on their own. But for students to learn from these technologies they must be actively engaged in the learning process. Zaki et al., (2026) observed the potential for AI technologies to facilitate a variety of stages of SRL and noted concerns about the issue of misinformation and over-reliance on AI. Likewise, Myagmarkhorloo et al., (2026) suggested that the key to good self-regulation is for learners to plan, monitor and reflect on their learning. Thus, AI can be a valuable component in education when students are in control of their learning and are given autonomy in their learning.

Self-regulated learning is related to metacognitive awareness in that both concepts refer to understanding, monitoring and controlling one's own learning processes. Pupils who set targets for learning, keep track of their learning and assess themselves are more likely to identify their strengths and weaknesses. Metacognitive awareness helps students to understand how they learn and self-regulated learning helps the students to put this understanding into practice by applying to their learning strategies.

Research Objectives

- To examine the effect of AI-assisted education on students’ metacognitive awareness.
- To investigate the relationship between AI-assisted education and students’ cognitive flexibility.
- To examine the role of self-regulated learning in developing students’ metacognitive awareness.

Research Questions

1. Does AI-assisted education significantly influence students’ metacognitive awareness?
2. Does AI-assisted education significantly influence students’ cognitive flexibility?
3. Does self-regulated learning significantly contribute to students’ metacognitive awareness?

Problem Statement

The growing integration of Artificial Intelligence (AI) in educational settings has opened the door to opportunities for students to access information, to get individual academic support and to enhance their learning experience. Nevertheless, the increased reliance on AI-based teaching aids also poses a question of how students can think independently, keep track of their learning, and control their learning process themselves. While AI tools can offer instant explanations and academic support, their impact on fostering students' metacognitive development is a crucial aspect that warrants further research. Metacognition Awareness (MA) has been recognized in the past as key to improving learning outcomes and cultivating independent thinking skills. In addition, cognitive flexibility allows students to think in multiple ways and can change their thinking strategies; self-regulated learning can help students in goal setting, monitoring learning, and self-evaluating (Asad et al., 2026). While it is recognized that AI has been already integrated into higher education, the relationships between AI-assisted education and students' metacognitive awareness and the roles of cognitive flexibility and SRL in this relationship remain unclear. Thus, the purpose of this study was to explore the impact of AI-supported learning on metacognitive awareness of students on the basis of cognitive flexibility and SRL among university students in Pakistan (Aurangzeb, 2025).

Significance of the Study

This study is significant because it explores how AI-assisted education can contribute to students' metacognitive awareness by examining the roles of cognitive flexibility and self-regulated learning. The findings may help university students understand the importance of using AI tools effectively while maintaining independent thinking, learning responsibility, and critical reflection. The study may also provide valuable insights for teachers and educational institutions regarding the integration of AI technologies into teaching and learning practices. Furthermore, it may encourage educators to develop learning strategies that strengthen students' ability to monitor their understanding, adapt their thinking, and regulate their academic activities. The research may also contribute to the existing literature in educational psychology by providing a better understanding of the relationship between AI-assisted education and students' cognitive and learning-related abilities, particularly within the context of higher education in Pakistan.

Literature Review

AI-Assisted Education and Students' Metacognitive Awareness

Personalized learning, interactive feedback, and intelligent academic support are among the key features that make AI-assisted education a promising solution for improving students' learning experiences.AI-assisted education holds significant promise for enhancing students' learning experiences through personalized instruction, interactive feedback, and intelligent academic support, which have garnered growing attention in educational research. Students can get explanations, investigate new topics, and get help based on their own learning requirements by using AI-powered learning applications. Artificial Intelligence can aid educational advancement by furnishing personalized learning opportunities and boosting educational processes. Likewise, Özdere (2026) conducted a systematic review of the use of artificial intelligence in higher education and came up with four relevant topics for the adoption of AI: Student assessment, student profiling, adaptive systems, and intelligent tutoring. The advancements indicate that AI-driven education can offer students more flexible learning spaces, enabling them to take charge of their own learning.

Metacognition is a significant aspect that affects student's understanding and management of learning activities. It requires thinking skills and understanding of personal thinking processes, knowledge and learning strategies as well as the ability to assess academic understanding. The theoretical basis of metacognition was laid by Mughal et al., (2026) who described ways in which people became conscious of and controlled their thinking processes. Jaworski (2026) extended the idea and identified two dimensions of cognition knowledge and regulation of cognition. Their research showed that metacognition is beneficial for anyone to reflect on what they know, uncover what they don't, and choose an appropriate strategy to enhance learning. The metacognitive awareness is especially crucial in the context of technology-supported learning, where learners need to critically process information and keep track of their learning progress.

AI-driven education and metacognition can be understood by students' engagement with the AI-generated information and feedback. By using AI tools to analyze and contrast explanations, to find errors, to pose further questions, and to think through learning concepts, students can gain deeper insights into how they learn. But relying too much on AI responses could diminish independent thinking and independent assessment opportunities. Kasneci et al. (2023) talked about the role of large language models in education, highlighting their potential and challenges, as well as the need for critical thinking and responsible use. Likewise, Tlili et al. (2023) explored the potential of education applications of ChatGPT and identified the importance of using appropriate pedagogical guidance. Hence, the use of AI in education could enhance metacognitive awareness in cases where students actively interact with AI tools, and leverage them to aid reflection instead of relying on them to replace independent study.

Cognitive Flexibility as a Predictor of Students' Metacognitive Awareness

Cognitive flexibility is acknowledged as a key cognitive ability that affects the way students think, process and react to information as well as adapt to academic situations. It allows pupils to think of others' ideas, to think of alternative solutions and to adjust their methods when the initial solutions do not work. İdawati et al., (2020) have made three key points about cognitive flexibility: knowing what alternatives are available, being willing to be flexible, and believing that he or she can adapt to new situations. Musullulu et al., (2025) then elaborated on this, stressing the capacity to offer various possible explanations and to identify several different solutions for difficult situations. In the same way, Karaoglan Yilmaz et al. (2025) noted the need for cognitive flexibility when mastering complex and new knowledge. The viewpoints mentioned above imply that cognitive flexibility can help students to manage various learning scenarios in order to be flexible learners.

Cognitive flexibility becomes especially important in AI-supported education because students may come across different explanations, sources of information, and ways of solving problems. It helps them consider different ideas, adjust their thinking, and choose suitable approaches when learning with AI tools. The use of AI can provide students with the opportunity to look at the

answer from another point of view, to ask questions from other perspectives, and to retake their original thinking on academic concepts. These relationships can inspire pupils to think flexibly and to get out of ruts. Gyimah et al. (2026) noted that adaptive learning and intelligent tutoring are two significant areas of using AI in education.

Furthermore, cognitive flexibility is theoretically related to metacognitive awareness as students need to be aware of their thinking process and assess the effectiveness of their learning strategies in specific learning contexts. Flexible learners will re-evaluate inaccurate thinking, look for alternative strategies and adapt their strategies as needed when something goes wrong. These skills are related to metacognitive monitoring and regulation that help students to understand and regulate their learning processes. A metacognitive process is when one is aware of and regulates cognitive activities, and when one monitors and evaluates thinking processes. Furthermore, Çutuk et al., (2026) showed how flexible thinking is important for developing alternative interpretations and how it helps to deal with challenging situations. Thus, cognitive flexibility could influence the metacognition of students by making them aware of their learning problems, assess alternative learning approaches, and make suitable changes in their learning activities.

Self-Regulated Learning and Its Contribution to Metacognitive Awareness

Self-regulated learning is a concept that has been discussed extensively in the field of education and is an important concept that explains how students plan, monitor, control and evaluate their learning process. It focuses on the role of students in setting learning objectives, choosing learning strategies, planning the time needed and monitoring their learning. Self-regulated learning was presented by Efklides et al., (2024) as a cyclical process consisting of the forethought, performance and self-reflection phases. Likewise, Dignath et al., (2026) defined SRL as an active process in which students set goals and monitor their cognition, motivation and behavior. A comprehensive review of the self-regulated learning models by Amini Farsani et al., (2019) also mentioned the importance of planning, monitoring and reflecting in successful learning. The theoretical perspectives show that by using self-regulated learning, students can be more independent, responsible and purposeful in learning both inside and outside the classroom.

The use of AI tools to help with learning resources and materials may provide further opportunities for students to apply their SRL skills. By leveraging AI tools, students can organize their academic tasks, clarify complex concepts, receive feedback, recognize their learning gaps, and track their improvement. These features could facilitate various phases of SRL, such as planning learners' activities, judicious assessment of their knowledge and strategies, and future adjustments of their knowledge and strategies. In a qualitative systematic review of using AI to facilitate SRL in higher education, Mustopa et al., (2020) found that the potential of AI tools such as chatbots, adaptive feedback systems, and other applications has great potential to support students' learning autonomy. Likewise, Krieger et al. (2022) explored the relationship between artificial intelligence and SRL, and emphasized the increasing number of studies in AI-assisted learning regulation. Additionally, opportunities for learning strategies and metacognitive monitoring have been recognized in the field of educational chatbots. The results in this study suggest that the use of AI in education can complement SRL if students continue to be engaged in their own learning process.

There is a strong theory-to-practice relationship between SRL and metacognitive awareness in that both concepts include students' awareness and control of mental processes. Students' metacognitive awareness is to identify what they know and how they learn while self-regulated learning allows students to use their metacognitive knowledge in planning, monitoring, and evaluating their academic activities. Learners who monitor their own learning progress will be more likely to discover areas of knowledge they don't yet have, recognise some learning strategies that are less effective, and know what to do to improve their performance. Listed knowledge and regulation of cognition as critical factors of metacogniton. Similarly, described that the self-regulated learners continuously check their performance and think about their learning results. In addition, pointed out that the metacognitive monitoring and control is capable of explaining the self-regulated learning processes. Thus, the self-regulated learning could contribute to the development of students metacognitive awareness, as it is able to instill the students to be active in learning, self-evaluation, and continuous improvement in their learning.

Research Gap

While there are many studies that have focused on the application of artificial intelligence in education, on personalized learning, or on students' learning, there has been scant research that has attempted to explore how AI-based education has been specifically related to the development of students' metacognitive awareness. Previous studies have concentrated mainly on the role of AI on learning outcomes, academic performance, and technology acceptance, and the synergy between cognitive flexibility and SRL on metacognitive awareness is not well explored. Additionally, cognitive flexibility and SRL have been studied separately from one another in educational and psychological studies, leaving the study of both together within AI-supported learning environments

unexplored (Sadaf et al., 2026). This restriction has become a call to action for further research into the role these factors play in students' awareness and control of their cognition. Specifically, from the point of view of Pakistan's higher education system, there is meager empirical evidence which emphasizes the need to explore these connections between university students. Thus, this study aims to bridge this gap by exploring the link between AI-enhanced learning and metacognitive awareness of students, as well as the interplay of cognitive flexibility and SRL.

Hypothesis

H1: AI-assisted education has a significant positive effect on students' metacognitive awareness.

H2: AI-assisted education has a significant positive effect on students' cognitive flexibility.

H3: Self-regulated learning has a significant positive effect on students' metacognitive awareness.

Conceptual Framework

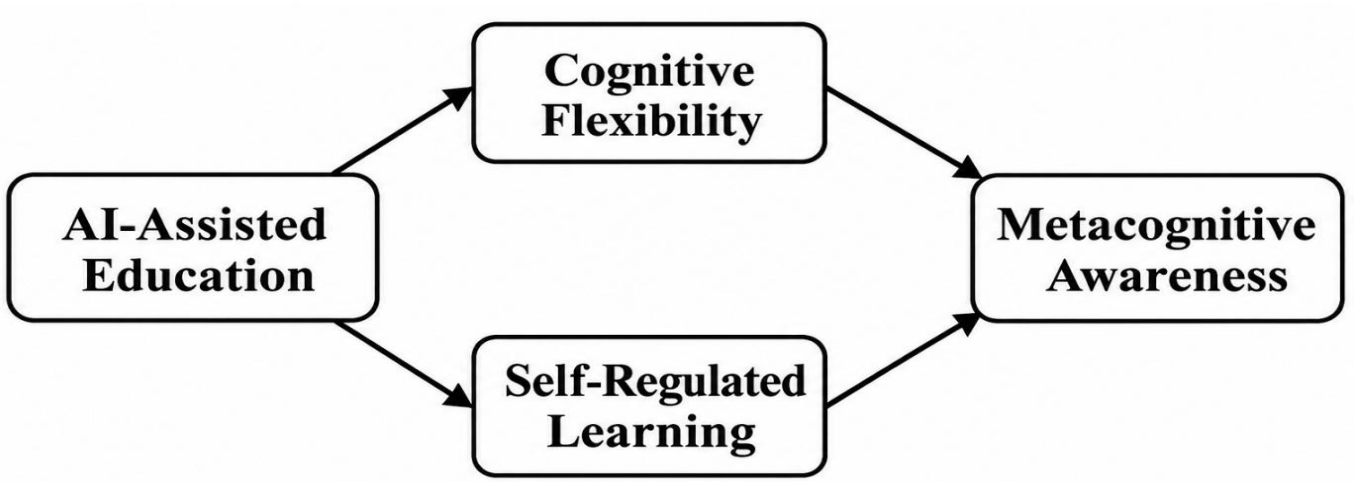

Fig 1: Conceptual Framework

Methodology

Research Design

The quantitative research approach used in the study is cross-sectional research, which examines the effect of AI-assisted education on students' metacognitive awareness, focusing on the students' cognitive flexibility and self-regulated learning. Primary data was collected using a structured questionnaire from the University students in Pakistan. The quantitative approach was used because it allowed the researcher to measure the study variables and also to analyze the relationships between the variables by means of statistical analysis. Data were gathered at the one-time point.

Population of the Study

The target population comprised of the university students of public and private university across Pakistan. The target population included students from various disciplines (social sciences, management sciences, natural sciences and information technology). The possible recruiting institutions were found to be University of the Punjab, Bahauddin Zakariya University, Government College University Faisalabad, International Islamic University Islamabad, University of Karachi, University of Peshawar and University of Balochistan. It was an opportunity to reach institutions representing various geographical regions of Pakistan, and also students having a variety of academic backgrounds and knowledge of the use of AI-assisted educational tools.

Sample Size and Sampling Technique

For the study, a total sample of 347 university students was determined. A non-probability technique of convenience sampling was used to select students who were available and willing to take part in the study. The samples were targeted to students enrolled in higher education institutions who were familiar with the AI assisted learning tools, such as ChatGPT, Gemini, and other AI learning

platforms. The questionnaire was sent to the university student networks and on-line academic communities by using Google Forms.

Table 1: Distribution of Proposed Sample Size Across Selected Universities in Pakistan (N = 347)

Geographical Area	University/Institution	Proposed Respondents
Punjab	University of the Punjab	60
Punjab	Bahauddin Zakariya University	55
Punjab	Government College University Faisalabad	50
Islamabad	International Islamic University Islamabad	50
Sindh	University of Karachi	48
Khyber Pakhtunkhwa	University of Peshawar	44
Balochistan	University of Balochistan	40
Total	7 Institutions	347

Data Collection Instrument and Measurement Scales

The data used in this study were primary data and it was obtained by administering a structured questionnaire to the respondents, using Google forms. In a sense, the self-administered element of the questionnaire refers to how the questionnaire is completed: the questions are read to the individual and the individual answers the questions without the presence of an interviewer. The items on the questionnaire were not created from scratch but rather have been adapted from existing measurement instruments and relevant literature in the field.

There were two parts to the questionnaire. The first section gathered the demographic aspects of the respondents such as gender, age, academic level and educational background. The second section was designed to assess the four research variables: AI-assisted education, cognitive flexibility, SRL, and metacognitive awareness. All the measurement items were tailored and adapted to be suitable for the high education environment assisted by AI.

The study employed structured measurement instruments to assess the research variables, including cognitive flexibility, self-regulated learning, and metacognitive awareness. The questionnaire items related to AI-assisted education were developed and adapted from relevant educational literature to reflect the study's research objectives. All items were measured using a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5).

Statistical Treatment of Data

The data collected were analyzed by Statistical Package for the Social Sciences (SPSS). Demographic data of the respondents were summarized by descriptive statistics such as frequencies and percentages. The reliability and internal consistency of the measurement scales was assessed using Cronbach's alpha. The relationships among AI-assisted education, cognitive flexibility, SRL and metacognitive awareness were examined using Pearson correlation analysis. To test the three proposed hypotheses, simple linear regression analysis has been used. H1 explored how AI-supported learning influences metacognitive awareness, H2 explored how AI-supported learning influences cognitive flexibility, and H3 explored how SFL influences metacognitive awareness

Ethical Considerations

The principles for research were adhered to throughout. Respondents were not forced to participate and their informed consent was obtained prior to answering the questionnaire. The respondents were assured that their responses will be confidential and will be used for academic research only. There was no need to provide personally identifying information and respondents could opt out of the process.

Table 2: Demographic Characteristics of Respondents (N = 347)

Demographic Variables	Categories	Frequency (N)	Percentage (%)
Gender	Male	181	52.2
	Female	166	47.8
	Total	**347**	**100.0**
Age	18–22 years	145	41.8
	23–27 years	124	35.7
	28–32 years	53	15.3
	Above 32 years	25	7.2
	Total	**347**	**100.0**
Academic Level	Undergraduate	183	52.7
	Master's	112	32.3
	MPhil/MS	40	11.5
	PhD	12	3.5
	Total	**347**	**100.0**
Educational Background	Social Sciences	105	30.3
	Management Sciences	91	26.2
	Natural Sciences	78	22.5
	Information Technology	73	21.0
	Total	**347**	**100.0**

The demographic data of 347 university students who answered the questionnaire is presented in Table 2. With respect to gender, there was a fairly even distribution with 181 (52.2%) men and 166 (47.8%) women respondents. In terms of age, the majority of respondents were between 18 and 22 years (41.8%), followed by those aged 23–27 years (35.7%), 28–32 years (15.3%), and above 32 years (7.2%). Academic-level-wise, most of the respondents were undergraduate students (52.7%), followed by Masters (32.3%), MPhil/MS (11.5%) and PhD (3.5%). Education-wise, the students from social sciences made up 30.3% of the samples, followed by management sciences 26.2%, natural sciences 22.5% and information technology 21.0%. The findings suggest that the study was conducted with students from various backgrounds and academic achievements, as it offers a good representation of the experiences of students in the university with the use of AI in education.

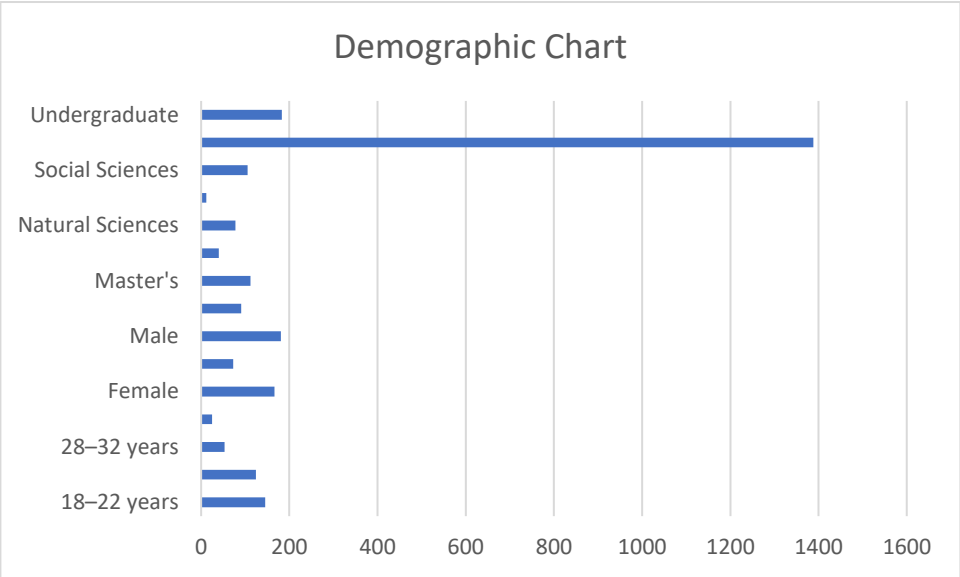

Fig 2: Demographic chart

Table 3: Reliability Analysis of Research Variables (N = 347)

Variables	Number of Items	Cronbach's Alpha
AI-Assisted Education	5	0.861
Cognitive Flexibility	5	0.843
Self-Regulated Learning	6	0.879
Metacognitive Awareness	6	0.892
Overall Reliability	22	0.918

Table 3 shows the reliability analysis of all the research variables obtained from the Cronbach's Alpha test. The results show that the reliability coefficient of the education received through artificial intelligence is 0.861 and cognitive flexibility is 0.843. Likewise, the Cronbach's alpha value of self-regulated learning was 0.879 and metacognitive awareness was 0.892. Overall, the internal consistency of the 22 measurement items (the reliability coefficient 0.918) is excellent. Nunnally and Bernstein (1994) suggested that Cronbach's Alpha score should be 0.70 or higher for research. Thus, the four variables have acceptable levels of reliability and can be used for further statistical analysis.

Table 4: Simple Linear Regression Analysis of AI-Assisted Education Predicting Students' Metacognitive Awareness (N = 347)

Predictor	B	Std. Error	Beta (β)	t-value	Sig.
Constant	1.124	0.218	—	5.156	0.000
AI-Assisted Education	0.652	0.058	0.694	11.241	0.000

Model Summary

R	R^2	Adjusted R^2	F-value	Sig.

0.694	0.482	0.481		126.360	0.000

The regression results showed that there was a significant positive effect on students' metacognitive awareness for the variables of AI-assisted education (β = 0.694, t = 11.241, p < 0.001). The positive regression coefficient (B = 0.652) indicates that the amount of students' metacognitive awareness increases with the amount of AI supported education. Moreover, 48.2% of the variation in metacognitive awareness (R^2 = 0.482) is explained by the model. The F-value is 126.360 it means that the regression model is statistically significant. So, H1 is accepted.

Table 5: Simple Linear Regression Analysis of AI-Assisted Education Predicting Cognitive Flexibility (N = 347)

Predictor	B	Std. Error	Beta (β)	t-value	Sig.
Constant	0.876	0.176	—	4.977	0.000
AI-Assisted Education	0.741	0.049	0.781	15.122	0.000

Model Summary

R	R^2	Adjusted R^2	Std. Error of Estimate	F-value	Sig.
0.781	0.610	0.609	0.412	228.710	0.000

ANOVA Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	38.826	1	38.826	228.710	0.000
Residual	58.571	345	0.170	—	—
Total	97.397	346	—	—	—

The regression analysis reveals a positive and strong relationship between using AI in the education sector and students' cognitive flexibility. The results indicate that AI supported education positively and significantly influences cognitive flexibility (B = 0.741, β = 0.781, t = 15.122, p < 0.001). This suggests that students who interact more with AI tools for learning are more cognitively flexible, being able to think in different ways, such as: use of alternative viewpoints, flexibility in thinking strategies, and different approaches to academic problems. In addition, the model summary shows a high positive correlation between AI-assisted education and cognitive flexibility (R = 0.781), and that 61.0% of the variation in cognitive flexibility is captured by AI-assisted education. The adjusted value of R squared was also 0.609, which means that the model's ability to explain the data is not changing. Furthermore, results of ANOVA test showed that the regression model is statistically significant (F = 228.710 with p value < 0.001). The regression coefficient indicates that an increase of one unit of AI-assisted education is related to an increase of 0.741 unit of cognitive flexibility. So it is proposed that H2 is supported based on these proposed results.

Table 6: Simple Linear Regression Analysis of Self-Regulated Learning Predicting Students' Metacognitive Awareness (N = 347)

Predictor	B	Std. Error	Beta (β)	t-value	Sig.
Constant	0.934	0.184	—	5.076	0.000
Self-Regulated Learning	0.728	0.052	0.765	14.000	0.000

Model Summary

R	R^2	Adjusted R^2	Std. Error of Estimate	F-value	Sig.
0.765	0.585	0.584	0.428	196.000	0.000

ANOVA Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	35.890	1	35.890	196.000	0.000
Residual	63.199	345	0.183	—	—
Total	99.089	346	—	—	—

The regression analysis shows that the self-regulated learning significantly and positively affects the students' metacognitive awareness (B = 0.728, β = 0.765, t = 14.000, $p < 0.001$). The discovery implies that students who are actively involved in the planning of their academic activities, in monitoring their learning process and in evaluating their performance, are more aware of their cognitive process. From the model summary, a high value of correlation coefficient, 0.765, was obtained, which means that there is a strong positive relationship between self-regulated learning and metacognitive awareness. Besides, the coefficient of determination ($R^2 = 0.585$) shows that the variance of students' metacognitive awareness is explained by self-regulated learning by 58.5%. The R^2 value adjusted to 0.584 is an additional indication of the explanatory power of the model. The ANOVA results also show that the regression model is also statistically significant ($F = 196.000$, $p<0.001$). The positive regression coefficient (B = 0.728) means that when the self-regulated learning increases by one unit, the metacognitive awareness increases by 0.728 unit. As a result, the supports for H3 are proposed.

Discussion

The results supported H1, showing that the use of AI in education positively influences students' metacognitive awareness. This suggests that AI-based learning tools can help students better understand their learning process, recognize areas where they need improvement, and keep track of their academic progress. These tools also allow students to review their understanding, identify learning difficulties, and make better decisions about how to improve their learning. Overall, the findings highlight the importance of AI in helping students become more aware of their learning needs and abilities. Students can receive alternative explanations, immediate feedback, and further learning support from AI applications, which can foster reflection and independent thought among students. The results confirmed previous research by Balouch et al. (2025) that showed how AI can be used to enhance personalized learning and enhance educational experiences. Likewise, Yurt (2025) noted that, if used appropriately, generative AI tools can contribute to student's understanding and their academic growth. The results are also consistent with the findings of Rasheed (2025) who pointed out the significance of metacognitive awareness to monitor and regulate personal learning processes.

The findings also confirmed that there is a solid positive impact of the use of AI in teaching on the cognitive flexibility of students, which lent support to H2. It suggests that students who use an AI-powered learning tool could be better able to think outside the

box in learning situations, look for other solutions, and change their thinking process when encountering learning problems. AI tools offer opportunities for comparisons of explanations, and for multiple approaches to complex concepts, which might help foster flexibility in thinking. These results are similar to those of Varghese et al., (2025), who defined cognitive flexibility as perceived alternatives and adapting to new contexts. Dennis and Vander Wal (2010) also pointed out the need to think differently, and to create other explanations when facing challenging situations. In addition, BinJwair (2026) pointed out the contribution of adaptive and personalized AI technologies to meeting the varied educational needs. Thus, AI in education could create the space to foster students' flexible thinking.

This study's results offer valuable insights into the role of AI-driven education, cognitive flexibility, SRL, and metacognition in higher education in Pakistan. Based on the results obtained, the present study indicates that the use of Artificial Intelligence technologies can facilitate students' cognitive and learning-related development when they are actively involved, think flexibly and apply independent learning strategies. The educational value of AI, however, hinges on the ability of the students to assess AI-generated content, not on auto-generated answers. This is in line with Priyambudi et al. (2026) that highlighted the educational opportunities and challenges of ChatGPT, emphasizing the need for responsible use and specific pedagogical guidance. In the same way, Lee (2026) emphasized the role of self-regulatory learning processes to effective learning. The results of the present study thus underscore the need to combine AI-based learning tools and teaching methods that foster reflection, independent decision making, flexibility, and self-regulated learning for university students.

Conclusion

In this study, the role of cognitive flexibility and self-regulated learning (SRL) among university students in Pakistan and its impact on metacognitive awareness of students through AI-assisted education were investigated. The results showed that the use of AI support in education was highly effective in improving the metacognitive awareness and cognitive flexibility of the students. Moreover, the contribution of self-regulated learning to the students' metacognitive awareness was shown as significant positive contribution. AI education tools play a crucial role in helping students learn and think flexibly through supporting their learning experiences and enhancing their understanding and monitoring of their thinking. The study also highlights the potential of AI in education to offer students opportunities for discovering alternate explanations, recognizing learning challenges, and enhancing their academic learning.

The study concludes that AI-supported learning can play an effective role in enhancing learning in conjunction with cognitive flexibility and the learning strategies of the students themselves. Students should be treated as tools that enrich their learning rather than replace or dictate their thinking and judgement and be held accountable for their own learning. Likewise, universities and educators should foster learning spaces that incorporate AI technologies and activities that enhance reflection, planning, monitoring and evaluation abilities. The results can offer practical recommendations for educational institutions in Pakistan for the proper integration of AI in higher education and can be useful for further studies on technology-driven learning and students' cognition.

Future Implications

In future studies, the impact of AI-assisted learning on students' metacognitive awareness should be explored further, with more psychological and educational factors, including critical thinking, learning motivation, students' digital literacy, academic engagement, etc. Future research can be carried out at various universities, academic departments, and geographical regions of Pakistan, to gain a wider perspective on students' experience with AI learning technologies. Longitudinal or experimental research designs could also be used in future studies to investigate the effects of ongoing interactions with AI tools on students' cognitive flexibility and self-regulated learning over time. In addition, the results presented herein can be applied by educational institutions and policymakers to provide support for the creation of classroom teaching methods in which AI is incorporated and which can support independent thinking, reflective learning, responsible use of technology and active participation in learning activities.

References

1. Holmes, N. (2019). *The Effectiveness of a Student Response System on Student Achievement in Third Grade Mathematics* (Doctoral dissertation, Grand Canyon University).

2. Bai, J. Y., Zawacki-Richter, O., & Muskens, W. (2022, September). Developing strategic scenarios for artificial intelligence applications in higher education. In *5th International Open and Distance Learning Conference Proceedings Book* (pp. 47-70).

3. Ji, C., & Tan, Q. (2026). The impact of artificial intelligence on students' metacognition: a systematic review. *Frontiers in Psychology*, *17*, 1947198.

4. Mazari, N. (2025). Building metacognitive skills using AI tools to help higher education students reflect on their learning process. *RHS-Revista Humanismo y Sociedad*, *13*(1), e4-1.

5. Akram, A., Kiren, A., Sabir, S., & Aslam, S. (2025). The effect of AI based scaffolding on problem solving and metacognitive awareness in learners. *The Critical Review of Social Sciences Studies*, *3*(3), 1074-1089.

6. Tezer, M. (2025). Metacognitive engagement in AI-supported learning: Frameworks, challenges, and transformations. In *Metacognition in Action-Insights into Learning, AI, and Self-Regulation*. IntechOpen.

7. Azevedo, R., & Wiedbusch, M. (2023). Theories of metacognition and pedagogy applied to AIED systems. In *Handbook of artificial intelligence in education* (pp. 45-67). Edward Elgar Publishing.

8. Mughal, I., Panhwar, M., & Akhtar, E. K. (2026). Cognitive Agility, Generative AI-Assisted Learning, and Problem-Solving Effectiveness among University Students: The Mediating Effect of Metacognitive Competence. *Journal of Global Social Transformation*, *2*(8.1), 293-310.

9. Shukla, A. (2026). Artificial Intelligence-Supported Metacognitive Learning in Higher Education: A Narrative Review. *Journal of Interdisciplinary Education, Learning and Knowledge Sciences*, *1*(1), 23-33.

10. Romdhoni, R. D., Arrasyid, R., Widodo, S., & Elviani, U. (2025). AI-driven learning analytics for self-regulated and metacognitive learning: a systematic review. *Intellect: Indonesian Journal of Learning and Technological Innovation*, *4*(02), 329-347.

11. Davor, I., Larbi, E., & Boateng, F. O. (2026, September). Artificial intelligence-supported learning and higher-order cognitive outcomes: the mediating role of metacognitive self-regulation. In *Frontiers in Education* (Vol. 11, p. 1855869). Frontiers Media SA.

12. Simo, L., & Lina, S. (2026). Profile analysis of college students' AI literacy and cognitive flexibility and its correlation with deep learning ability. *Frontiers in Psychology*, *17*, 1921158.

13. Dahri, N. A., Yahaya, N., Al-Rahmi, W. M., Aldraiweesh, A., Alturki, U., Almutairy, S., ... & Soomro, R. B. (2024). Extended TAM based acceptance of AI-Powered ChatGPT for supporting metacognitive self-regulated learning in education: A mixed-methods study. *Heliyon*, *10*(8).

14. Chen, S., Cheng, H., & Huang, Y. (2024). Emotion recognition in self-regulated learning: Advancing metacognition through AI-assisted reflections. In *Trust and inclusion in AI-mediated education: Where human learning meets learning machines* (pp. 185-212). Cham: Springer Nature Switzerland.

15. Ayaz, M. A., Karataş, F., & Yüce, E. (2026). Development and validation of the AI-enhanced Self-Regulated Learning (AI-SRL) scale. *RIED-Revista Iberoamericana de Educación a Distancia*, *29*(1), 185-216.

16. Zaki, S., Ali, I., Jafar, H. Y., & Amir, Z. (2026). The Impact of Artificial Intelligence-Supported Learning on Metacognitive Awareness and Critical Thinking Skills in Education: The Mediating Effect of Self-Regulated Learning. *Journal of Global Social Transformation*, *2*(9.1), 355-368.

17. Myagmarkhorloo, C., Ganzorigt, B. U., & Habók, A. (2026). Student engagement and self-regulated learning across standard and AI-enhanced flipped learning: a within-subjects longitudinal study. *Frontiers in Psychology*, *17*, 1936442.

18. Asad, M. M., Soomro, S., Nawab, A., & Almusharraf, N. (2026). Impact of artificial intelligence driven flipped classroom to enhance students' self-regulated learning: Innovative practices from the context of Pakistan. *Learning Futures and Emerging Technologies*, 1-23.

19. Aurangzeb, M., & Uddin, S. S. (2025). The artificial intelligence (AI) era: Challenges and opportunities for Pakistan and the Global South. Journal of Current Sign Review, 3(2), 254–264. https://currentsignreview.com/index.php/JCS/article/view/155/115

20. Özdere, S. (2026). Chatwise: Adaptive support for students' self-regulated learning in generative ai–mediated environments.

21. Mughal, I., Panhwar, M., & Akhtar, E. K. (2026). Cognitive Agility, Generative AI-Assisted Learning, and Problem-Solving Effectiveness among University Students: The Mediating Effect of Metacognitive Competence. *Journal of Global Social Transformation*, *2*(8.1), 293-310.

22. Jaworski, T. V. (2026). IMPACT OF AI-ASSISTED SECONDARY SCIENCE LEARNING AND METACOGNITIVE STRATEGIES ON STUDENT PERFORMANCE.

23. Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., ... & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and individual differences*, *103*, 102274.

24. Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart learning environments*, *10*(1), 15.

25. İdawati, İ., Setyosari, P., Kuswandi, D., & Ulfa, S. (2020). Investigating the effects of problem-solving method and cognitive flexibility on improving university students' metacognitive skills. *Journal for the Education of Gifted Young Scientists*, *8*(2), 651-665.

26. Musullulu, H., Garcia-Orza, J., Gómez Vázquez, D., & Garcia-Sanz, S. (2025). Cognitive control and metacognitive awareness: do they shape academic achievement in university students?. *Frontiers in Psychology*, *16*, 1633996.

27. Karaoglan Yilmaz, F. G., & Yilmaz, R. (2025). Exploring the role of self-regulated learnings skills, cognitive flexibility, and metacognitive awareness on generative artificial intelligence attitude. *Innovations in Education and Teaching International*, *62*(5), 1682-1695.

28. Gyimah, I. O., Ackon, J., & Frimpong, K. O. (2026). Metacognitive knowledge and mathematics engagement among senior high school students: Mediating role of cognitive flexibility. *International Journal of Mathematics and Mathematics Education*, *4*(1), 40-54.

29. Çutuk, S., Çutuk, Z. A., Aydoğan, R., Perez, J., & Prieto-González, P. (2026). The Serial Mediating Role of Cognitive Flexibility and Digital Literacy in the Relationship Between Metacognitive Awareness and Digital Well-Being. *European Journal of Investigation in Health, Psychology and Education*, *16*(9), 127.

30. Efklides, A., & Schwartz, B. L. (2024). Revisiting the metacognitive and affective model of self-regulated learning: Origins, development, and future directions. *Educational Psychology Review*, *36*(2), 61.

31. Dignath, C., van Berk, B., & Vosniadou, S. (2026). A systematic review on the development of self-regulated learning. *Learning and Instruction*, *106*, 102433.

32. Aurangzeb, M. (2025). Artificial intelligence era: Challenges and opportunities for Pakistan and Global South. https://www.morebooks.de/shop-ui/shop/product/9786209354588

33. Amini Farsani, M., Abdollahzadeh, E., & Beikmohammadi, M. (2019). Self-regulated learning, metacognitive awareness, and argumentative writing. *Writing & Pedagogy*, *11*(2), 195-222.

34. Mustopa, N. M., Mustofa, R. F., & Diella, D. (2020). The Relationship between Self-Regulated Learning and Learning Motivation with Metacognitive Skills in Biology Subject. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia)*, *6*(3), 355-360.

35. Krieger, F., Azevedo, R., Graesser, A. C., & Greiff, S. (2022). Introduction to the special issue: the role of metacognition in complex skills-spotlights on problem solving, collaboration, and self-regulated learning: Introduction to the special issue: the role of metacognition in complex skills-spotlights on problem solving, collaboration, and self-regulated learning. *Metacognition and Learning*, *17*(3), 683-690.

36. Sadaf, T., Shahzadi, N., Kulsoom, A., & Akbar, A. (2026). The effect of artificial intelligence-supported education on students' cognitive flexibility: The mediating role of learning engagement. *Journal of Global Social Transformation*, *2*(9.3), 161-177.

37. Balouch, F. A., Rasheed, B., Naz, Z., & Zahoor, A. (2025). The role of artificial intelligence in enhancing self-regulated learning and academic performance. *The Critical Review of Social Sciences Studies*, *3*(4), 572-586.

38. Yurt, E. (2025). The self-regulation for AI-based learning scale: Psychometric properties and validation. *International Journal of Current Educational Studies*, *4*(1), 95-118.

39. Rasheed, T. (2025). Metacognitive skill development through AI enhanced educational platforms: A psychological perspective. *The Critical Review of Social Sciences Studies*, *3*(3), 404-420.

40. Varghese, M. A., & Sharma, P. (2025). Tracing 40 years of research on Artificial Intelligence and human metacognition from 1985 to 2024. *Discover Psychology*, *5*(1), 187.

41. BinJwair, A. (2026). Adaptive AI-generated feedback in higher education: exploring associations with cognitive flexibility and academic psychological safety among engineering students. *Frontiers in Psychology*, *17*, 1820714.

42. Priyambudi, S., Setyowati, Y., & Ritonga, A. S. (2026). A Project-Based Hybrid Learning Model Using Artificial Intelligence to Enhance Students' Self-RegulatedLearning. *Jurnal Informatika dan Teknologi Pendidikan*, *6*(2), 139-154.

43. Lee, H. (2026). Self-Regulated Learning in AI-Supported Environments: Heterogeneous Achievement Associations and Learner-AI Interaction Patterns. *Available at SSRN 7542380*.



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