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The Effect of Artificial Intelligence-Supported Education on Students' Cognitive Flexibility: The Mediating Role of Learning Engagement

Dr. Tahira Sadaf¹, Neelam Shahzadi², Asma Kulsoom³, Ali Akbar⁴

¹ Associate Professor, Institute of Agricultural and Resource Economics, Faculty of Social Sciences, University of Agriculture, Faisalabad, Pakistan.

Email: tahira.sadaf@uaf.edu.pk

² Graduated from University of Engineering and Technology, Lahore, Pakistan.

Email: neelamshahzadi520@gmail.com

³ MPhil, Metro Politen University.

Email: asmakolsoom789@gmail.com

⁴ Department of Computer science, University of Education, Lahore

Email: Aliakbarlaaffi141@gmail.com

ARTICLE INFO	ABSTRACT
Submission: August 12, 2026 Revised: August 24, 2026 Accepted: September 10, 2026 Available Online: September 24, 2026 Keywords: Artificial Intelligence-Supported Education, Cognitive Flexibility, Learning Engagement, Artificial Intelligence in Education, University Students, Higher Education, AI-Supported Learning, Student Learning Corresponding author: Dr. Tahira Sadaf Email: tahira.sadaf@uaf.edu.pk	This study examined the effect of Artificial Intelligence-Supported Education on students' Cognitive Flexibility and explored the mediating role of Learning Engagement in this relationship. A quantitative, cross-sectional research design was adopted to collect data from 268 university students with experience of using AI-supported educational tools. Data were collected through a structured adopted questionnaire distributed online through Google Forms, and the completed responses were organized and analyzed using SPSS. Descriptive statistics, reliability analysis, Pearson product-moment correlation, simple linear regression, independent-samples t-test, one-way analysis of variance, and mediation analysis were employed to examine the study variables and their relationships. The findings revealed a significant positive relationship between Artificial Intelligence-Supported Education and students' Cognitive Flexibility, and AI-Supported Education significantly predicted students' Cognitive Flexibility. The results further demonstrated that Learning Engagement significantly mediated the relationship between AI-Supported Education and Cognitive Flexibility, while the remaining direct relationship indicated partial mediation. The demographic analysis also showed significant differences in Cognitive Flexibility across gender and age groups, whereas Learning Engagement did not differ significantly across academic levels. Overall, the study highlights the importance of AI-supported educational environments in promoting students' active involvement in learning and developing flexible cognitive responses. The findings provide useful implications for educators, researchers, and higher education institutions by emphasizing that the educational value of AI is strengthened when its use is integrated with meaningful learning activities that encourage student engagement, exploration, adaptation, and flexible thinking.

Introduction

Artificial Intelligence-Supported Education

Artificial Intelligence (AI) in education means using intelligent technologies to help students with various learning activities in different ways, including interactive, adaptive and individualized learning, and providing learning materials and activities based on learners' academic needs. Unlike traditional electronic learning aids, AI-based educational systems are able to develop learners'

academic skills, provide academic feedback and tutor learners in accomplishing academic tasks. With the rapid development of large-scale generative Artificial Intelligence (AI) in the field of education, individualized learning becomes a practical option. Many researchers also noted the recent trend of using AI in various areas of postsecondary education (PSE), including providing educational content and materials, academic feedback and support, and scaffolding learners to self-regulate their learning (Crompton & Burke, 2023). From these, we can recognize the rapid growth of using AI in higher education. Given the context, AI will play an increasingly important role in education. The importance of AI in education is found in how learning is altered with the addition of AI. For example, AI allows teachers to provide more individualized instruction and immediate formative feedback. The use of AI in the classroom allows teachers to provide more opportunities for students to engage in deep-level strategy.

(Long et al., 2026) completed recent meta-analyses on the effects of Generative AI on learning. The analyses concluded that the use of Generative AI positively impacted learning, in particular, the use of Generative AI improved cognitive engagement. The authors argued that Generative AI positively impacted learning because AI alters how students engage with academic content.

Although AI offers many potential benefits in education, its increasing use may also create some unintended challenges. When students rely heavily on AI-generated information and content, they may become less involved in critical thinking, reasoning, and evaluating information on their own. Over time, this dependence may affect their learning process and academic achievement (Hassan, 2026). Negative consequences of students' reliance on large language models have begun to emerge, including reduced engagement and disrupted classroom learning (Heung & Chiu, 2025). It may be necessary to provide pedagogical guidance to prevent students from developing over reliance on AI and encourage students to engage critically with the support of AI. Based on the results of recent studies, AI has the potential to change students' learning and alter the ways in which they approach learning and thinking. Students may gain the ability to approach problems and think in ways they were previously unable to, thanks to the various potential explanations and examples AI provides.

Cognitive Flexibility

Cognitive flexibility refers to the capability of an individual to take into account various possibilities and alterations, to adjust their way of thinking to various views, and to change their perspectives and ways of doing things. Rubin et al. (2010) viewed cognitive flexibility as comprises the awareness of various ways of acting, readiness to act in an alternative way, and faith in acting in a flexible way. Students need cognitive flexibility to resolve problems in their education. Flexibility is needed because students are presented with many different kinds of instructions and/or information, and they have to work with changing requirements, goals and learning objectives. If students become stuck with a certain approach, they cannot solve a problem, and if they remain inflexible, they will not be able to understand different ways of approaching the same problem.

AI can explain the same concept in different ways, give examples of problems and their solutions, and respond to related questions. These features can support students in their learning by encouraging them to review their answers and consider different ways of understanding and solving problems. A 2026 study provided evidence on 820 university students, and showed cognitive flexibility to be a major factor in the evaluation of students' perception about the role of interactive AIs in learning and students' confidence in learning (learning self-efficacy) in a positive light. Hence, researchers have implied that, in such cases, where students are required to interpret dynamically generated AIs and learn to think critically, cognitive flexibility becomes salient.

This interaction between AI in education and cognitive flexibility can be defined by the various ways AI allows students to think and learn in different ways. By using different kinds of AI in the classroom, students are able to engage in more deep learning and provide flexibility beyond fixed ways of thinking. Although the use of AI in education may help promote cognitive flexibility, students can become too reliant on AI to provide answers, thus restricting students' ability to think for themselves (Yamashita et al., 2021). Some studies have focused on the importance of cognitive flexibility with interaction AI in learning, and the results showed that the use of this technology had a positive impact on students' performance. Other studies have focused on the effects of using various AI technologies in the classroom and how it helps students think in different and flexible ways. Overall, the results showed that this kind of education promotes teaching that helps students think for themselves and beyond the constraints of traditional education (Thornton, 2026).

Learning Engagement

Learning engagement refers to the level of effort, attention, and involvement students show when taking part in academic activities. It includes their behavioral, emotional, and cognitive involvement in the learning process. Generally, learning engagement comprises of numerous elements, for instance, the physical and psychological faculty with which a student participates in a learning activity, the degree of a student's psychological investment, and a student's interest and enjoyment in academic activities. Fredricks

and his colleagues elaborate on the aforementioned engagement elements, and recommend that teachers consider the different contexts and features of a classroom when determining the extent to which students are engaged. Generally, engaged learners are interested in the subject matter and actively participate in the development of various cognitive learning strategies (Carroll et al., 2021).

Being behaviorally engaged reflects a student's physical and psychological participation in instructional activities, emotional engagement reflects a student's interest in, and feeling of enjoyment toward instructional activities. Cognitive engagement reflects a student's psychological investment to cognitively connect with, and understand, the subject matter. These elements of engagement are interacting, rather than singularly, existing in engagement. Among the features of AI in education are virtual tutors, Behavioral analytics tools, and the ability to automatically personalize learning. Each of these features has the potential to facilitate various forms of behavioral, emotional, and cognitive engagement in students (Halverson & Graham, 2019).

Digital, interactive, and personalized education aids can facilitate student engagement by helping students identify errors and providing alternate ways of understanding. Students can benefit from education aids that enable interaction and help them clarify their doubts. Student engagement is increasing as a result of the use of AI in higher education. In one study, the use of AI in higher education was found to increase student engagement and flow. The meta-analysis conducted by Buelow et al. (2018) also found that the use of ChatGPT in higher education improved behavioral, cognitive and emotional engagement.

There is sufficient evidence to indicate that the use of AI in education improve student engagement. Use of AI in education offers the opportunity to individualize and interactively customize instruction to meet student needs. The type and quality of pedagogical interaction offered by AI influences the level of engagement. In recent studies, it was found that the use of AI in education offers students the opportunity to interact with technologies that shape students' emotional experiences and engagement. From the studies, AI in education offers students the opportunity to participate meaningfully in education (Doo & Kim, 2024).

Learning Engagement as a Mediating Mechanism Between AI-Supported Education and Cognitive Flexibility

Engagement is the means by which students critically interact with and process educational technology (i.e. AI). Hence, engagement describes the psychological and behavioral means by which students interact with educational technology in a critical, constructive and creative manner. Generally, students, on their own, are unlikely to process educational technology in a critical, constructive and creative manner. AI educational technology presents students with suggestions, feedback, and alternatives to solutions to problems. Students' cognitive processes and strategies remain unchanged, if students remain passive and determined in their learning. Cognitive, behavioral and emotional involvement in learning facilitates students in critically and creatively processing suggestions and alternatives. Learning engagement thereby describes a cognitive process that drives students to evaluate and revise their assumptions and learning strategies. From an adaptation and integration perspective, learning engagement describes the cognitive process that drives students to critically engage with learning (Deng & Chen, 2025).

Focusing on learning engagement helps explain why students' psychological and behavioral involvement can act as a link between their interaction with educational technology and their cognitive learning processes in AI-supported learning environments. In this context, flow refers to a positive psychological state that can encourage students to become more deeply involved in the learning process (Alwahaishi & Ahmed, 2026). According to research, students psychologically engage with AI educational technology to explore alternatives to learning strategies and cognitive processes. A psychological experience, driven by flow, complements cognitive engagement.

Deep and meaningful learning can foster students' ability to generate various solutions to problems. There is ample evidence to support that students who engage with their learning (through various strategies like adjusting their goals and considering different forms of constructive and practical feedback) will improve their academic outcomes. Within learning, cognitive flexibility is reliant on students' inquiry, monitoring of their understanding, adjustment of learning strategies, and engagement with feedback. Fortunately, educational AI applications can be programmed to provide feedback. Thus, it is students' responsibility to seek and use the feedback to engage with learning to achieve enhanced cognitive outcomes. Evidence suggests that in educational contexts, AI can positively impact students' cognitive engagement (Usman et al., 2025).

Existing research provides enough support to examine learning engagement as a mediating factor between the use of AI in education and students' cognitive flexibility. The use of AI in educational settings can create more interactive and adaptive learning experiences, which may encourage students to engage more actively in the learning process. Learning engagement reflects students' behavioral, emotional and/or cognitive involvement with such learning opportunities. Cognitive flexibility reflects the learners' capacity to recognize and consider alternatives and/or other ways of thinking. Although studies have begun to explore cognitive

flexibility in the context of learning environments enhanced through the use of AI, the focus of these studies has primarily been on other areas, including moderator roles (i.e. self-efficacy), rather than learning engagement (Wu et al., 2026). Thus, exploration of this mediating role will further and more fully address the potential positive effects of integrating AI in education on students' cognitive development (BinJwair, 2026).

Research Objective

1. To examine the effect of Artificial Intelligence-Supported Education on students' cognitive flexibility.
2. To determine the effect of Artificial Intelligence-Supported Education on students' learning engagement.
3. To examine the mediating role of learning engagement in the relationship between Artificial Intelligence-Supported Education and students' cognitive flexibility.

Problem Statement

The use of Artificial Intelligence (AI) in education has changed the ways students learn and supports different ways of interacting with students. While much research exists on how AI impacts student performance, other psychological impacts of the technology have been less researched and understudied. It is understood that behavioral and emotional impacts of AI in education exist, but further research is warranted to provide evidence and understand how AI in the classroom impacts students' critical and creative thinking, and flexible cognition (Adaptive Thinking). Recently, systematic reviews and meta-analyses have reported evidence of AI in education positively impacting behavioral and emotional engagement. However, variability in cognitive engagement was reported and was influenced by the context of instruction and the level of integration of AI (Katalinic et al., 2026). Several other studies have researched cognitive flexibility in AI education, but have studied this construct in relation to other cognitive outcomes and/or as a factor that impacts the use of AI in education (Tezer, 2025). It is understood that engagement is impacted by the use of AI in education. Further, it is anticipated that cognitive flexibility may also be impacted by AI in education. This research aims to examine cognitive flexibility and the role of learning engagement to address this research-implementation gap.

Significance of the Study

The focus of this study is on cognitive flexibility, particularly Artificial Intelligence (AI) assisted learning's potential to foster it. The results of the study could assist teachers in designing AI-assisted learning environments to promote students' active engagement and to enhance their critical and creative thinking. The results of this study are important to education systems to help develop the integration of AI in education to enhance learning and teaching. The results may help researchers examine a different dimension of AI in education and promote cognitive development of students and go beyond assessing the effects of AI in education on traditional school learning and students' academic performance. The results could help promote the student-centered and responsible use of AI in education to encourage students to use their creative and critical thinking.

Literature Review

Artificial Intelligence-Supported Learning in Contemporary Education

Artificial Intelligence is changing the way students learn by offering personalized support, generating feedback, and providing useful examples. AI is no longer used only as a tool for finding information; it is increasingly becoming an active part of the learning process. As described by Yurt (2026), in recent years numerous innovative AI applications have emerged in higher education to enhance teaching and learning, and support the assessment function. In particular, systematic reviews and meta-analyses have shown that AI can shape learning, and bring about changes in student's academic performance and learning outcomes. Nonetheless, the extent to which these changes occur is context dependent. For instance, the teaching approach and duration of AI integration in teaching and learning affect the impacts of AI in education (Putri et al., 2025).

When integrating AI in education, the focus should be on how AI will transform teaching and learning, as opposed to when AI will become available. The main concern with using AI in education should not be on students' inability to interact with or evaluate AI's response, but students' inability or refusal to use AI as a tool to facilitate their learning. Recent studies show that education supported by large language models and AI can shape student's engagement in learning, and bring about positive and negative effects on student's learning. Thus, when integrating AI in education, it is important to pay attention to students' participation and engagement (Al-khresheh et al., 2026).

Students' Cognitive Flexibility in Learning

Cognitive flexibility helps a person change their way of thinking. It is necessary in different kinds of learning, as there are a variety of ways and methods to solve a problem. Learning to be flexible makes students able to think out of the box to reach solution to academic problems, and helps to realize new ways of approaching a problem, rather than using a same old, tried and tested way. It is a form of creativity. It is true that AI makes students able to see and understand multiple solutions and explanations to problems. Finding multiple ways of solving a problem certainly makes comparative thinking easier and gives students an opportunity to see various ways to approach and solve a problem. However, AI and multiple ways of coming up with a solution does not guarantee a person will be able to be flexibly creative and think outside the box (Toraman et al., 2020).

There are cognitive benefits of interacting with AI that require students to use higher order thinking skills. Recent studies focusing on interactive AI in the classroom have begun to study cognitive flexibility in relation to AI-based learning environments. This focus is behind studies that examine AI in the learning environment and student engagement. The literature tends to agree that cognitive flexibility is essential when learning involves information and solutions to problems that may not be mutually exclusive. The use of AI in learning environments may allow students to examine and challenge their previously held assumptions about problem solving by presenting them with varying responses to questions (Rhodes & Rozell, 2017). The evidence tends to focus on students' engagement and satisfaction rather than cognitive flexibility. Therefore, additional research may help determine the degree to which students' use of AI in an educational context helps students adapt and flex their thinking.

Learning Engagement as a Multidimensional Learning Process

Learning engagement is the level to which students participate in and express interest in academic activities. Fredricks et al. (2004) created a conceptualization of engagement with the dimensions of behavior, cognitive, and emotional. Behavioral engagement refers to how students increasingly participate and work in the classroom. Emotional engagement is how interested students are in the academic activities. Cognitive engagement is how students think and use their understanding in learning. Another important feature of this model is that engagement is an active process and therefore must be designed into classroom activities (Astleitner, 2018).

While use of technology in the classroom is designed to be interactive, in some cases it can facilitate students' learning in a passive manner. As with other areas of students' academic activities, technology can facilitate students' participation in activities such as questioning, and give feedback. AI can be integrated to help students to engage in learning activities and facilitate exploration. With the positive effects of ChatGPT on learning engagement reported by Heung and Chiu (2025) in their recent study, other studies also have shown that the use of Generative AI has a positive effect on learning engagement. Studies have shown that using Generative AI in the classroom is a developing trend. Therefore, there is a need for further research to assess engagement in the context of students interacting with Artificial Intelligence.

AI-Supported Education and Students' Learning Engagement

Studies show that using AI in education can help enhance student participation in learning. The use of AI in education provides opportunities for instant feedback and tutoring, as well as continuous interaction and engagement. This helps minimize obstacles that limits students' participation in academic activities. One study showed that the use of ChatGPT in classroom activities helped increase students' participation and engagement in learning. However, another study identified articles showing that the use of AI in education helped students' engagement and disengagement in learning. The differences in the findings show that AI does not influence learning participation either way. Rather, it shows that there is a need for consideration of the various ways through which the technology is integrated in the learning process as well as how learning activities are designed.

How AI is contextualized in teaching is given more focus in more recent research. Niyazova et al. (2026) examined 73 peer-reviewed articles and reported that the integration of AI in teaching to promote student engagement occurred in the context of interactive-type pedagogies such as scaffolded feedback and project-based learning. From this research, it can be suggested that AI in education helps to develop opportunities for student engagement, and how such opportunities are defined are attributed to how pedagogical design is integrated in teaching. The frame of research has shown that when integrating AI in teaching, the focus should be on identifying learning opportunities that engage students and promoting learning behaviors, and not on how students, by default, will attain given outcomes because of the integration of AI. Thus, AI should be evaluated based on learning outcomes and not be viewed as a substitute for teacher's skills and abilities (Geroche & Guay, 2024).

AI-Supported Education and Cognitive Flexibility

The relationship between AI-supported education and cognitive flexibility can be understood through the flexible way in which AI systems respond to different learning needs. By adapting their responses and support according to students' needs, AI-based tools may encourage students to consider different ideas, approaches, and ways of solving problems. AI systems can help students develop cognitive flexibility, for example, by suggesting and responding to different examples and solutions. AI systems can also help students generate and evaluate different approaches to a given academic problem by facilitating and fostering cognitive processes that go beyond the given and overt academic responses. Other studies have shown that students can develop cognitive flexibility when engaging with various types of AI systems. Most of the AI-supported systems can effectively respond to a variety of academic questions and concerns, and therefore prompt students to consider differences in responses. The variety in the responses fosters a need for students to be cognitively flexible (Jose et al., 2025).

However, the relationship between AI-supported learning and cognitive flexibility has not been explicitly and directly documented. Most of the recent scientific research has focused on the aforementioned variables of students' academic performance, desire and ability to learn. Thus, future studies may also want to explore whether AI-based educational systems assist students in cognitive flexibility and cognitive approach.

Learning Engagement and Cognitive Flexibility

Other researchers have connected learning engagement to cognitive flexibility for reasons including the way learners engage cognitive processes during the learning process. Stein et al. (2018) indicates that learners' level of cognitive engagement facilitates the development of higher-order skills and supports the analysis of multiple perspectives. The literature indicates that cognitive engagement focuses on higher-order thinking. Kuluşaklı (2025) support the association by placing cognitive engagement as the core dimension of psychological investment that learners bring to the learning process. Aydoğdua (2026) indicated that use of the language model to facilitate learning had a more significant positive effect on cognitive engagement as compared to other forms of engagement. In addition, a meta-analysis of research on Generative Artificial Intelligence (GenAI) indicated cognitive engagement as the most salient impact of engagement. Learners who use Generative AI to facilitate learning are given an opportunity to engage in cognitive processes to analyze and evaluate possibilities to amend their thinking. Thus, learning engagement is a potential mechanism to explain the link between the use of Generative AI in learning and cognitive flexibility. However, it is important to further test and research this relationship.

Learning Engagement as a Mediating Mechanism

AI-supported education offers opportunities for individualized interaction and feedback and allows for different kinds of learning contents and learning materials to be made available. Learning engagement describes the extent to which opportunities are exploited. The active use of opportunities requires engagement on the part of the student and may stimulate students to reflect upon and reconsider their ways of working and thinking. As such engagement promotes cognitive flexibility. There is a growing body of evidence in support of this argument. Ouyang (2025) showed that several kinds of student engagement are associated with different kinds of AI-support in learning, and that the quality of engagement is highly dependent on the ways in which AI is integrated in learning. (Fidan & Koçak Usluel, 2024) show that instructors play an active role in determining the extent to which students are cognitively engaged by AI in education. Research on the interaction between AI and education has paid more attention to learning outcomes, such as achievement and cognitive engagement, than to cognitive flexibility.

This extends the literature by considering how AI-supported education may promote students' cognitive flexibility, as opposed to just identifying whether or not an association exists. Based on the studies reviewed, it can be concluded that AI in education has mainly been developed to promote interactive learning. Student engagement has benefited from the use of AI in education; however, cognitive flexibility has not been assessed to the same extent. Research studies have demonstrated that engagement is associated with cognitive participation and have particularly emphasized the role of cognitive participation. The role of AI in learning and the relationship between learning engagement and cognitive flexibility has not been sufficiently clarified. This study, therefore, aims to determine the role of AI in education in strengthening students' cognitive flexibility; consider learning engagement; and explore how learning engagement relates to AI and cognitive flexibility (Pang et al., 2025).

Research Gap

Although recent research has established that Artificial Intelligence-supported learning can influence students' learning engagement, the existing literature remains concentrated on engagement, academic performance, motivation, and technology

acceptance, with comparatively limited attention to cognitive flexibility as a specific learning outcome. For example, (Balat, 2026) found positive effects of ChatGPT-supported learning on behavioral, cognitive, and emotional engagement, while (Feroze & Mangnejo, 2026) reported that the evidence on engagement is mixed and identified important gaps concerning students' deeper cognitive processes and learning behaviors. More recent reviews similarly demonstrate that AI can enhance engagement, particularly cognitive engagement, but emphasize that outcomes depend on learning strategies, teacher involvement, and educational context (Qassrawi & Al Karasneh, 2026). At the same time, recent research involving cognitive flexibility has examined it mainly as a moderating factor within interactive AI-supported learning rather than investigating whether AI-supported education directly contributes to cognitive flexibility and whether students' learning engagement explains this relationship. Therefore, a specific empirical gap remains in examining the integrated pathway from AI-supported education to cognitive flexibility through learning engagement. Addressing this gap can extend existing AI-in-education research from primarily examining engagement and performance toward understanding the cognitive process through which AI-supported learning experiences may be associated with students' ability to adapt their thinking and consider alternative approaches.

Hypotheses

- H1:** There is a significant relationship between Artificial Intelligence-Supported Education and students' cognitive flexibility.
- H2:** Artificial Intelligence-Supported Education significantly predicts students' cognitive flexibility.
- H3:** Learning engagement significantly mediates the relationship between Artificial Intelligence-Supported Education and students' cognitive flexibility.
- H4:** There is a significant difference in students' cognitive flexibility based on gender.
- H5:** There is a significant difference in students' cognitive flexibility across different age groups.
- H6:** There is a significant difference in learning engagement across different academic levels.

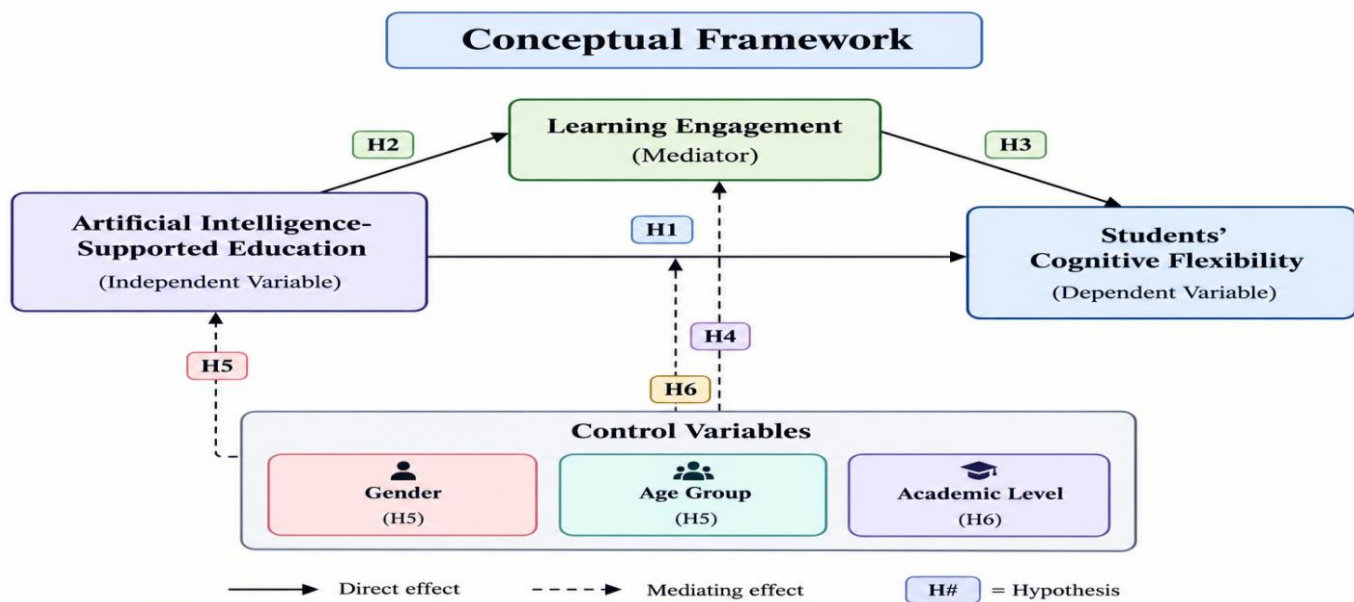


Fig. 1 Conceptual Framework

Methodology

Research Design

The study uses a quantitative, cross-sectional research design. Data were collected using a structured, predesigned questionnaire, and the study assessed Artificial Intelligence (AI) Supported Education and Learning Engagement, as well as analyzed students'

cognitive flexibility. The study was quantitative to measure the extent of the relationships and determine the predictors and the effects of the relationships, if any, among the study variables.

Population

The study's population consisted of university level students in Pakistan. The sample was drawn from Universities in the Punjab region and other Universities in Pakistan including Bahauddin Zakariya University Multan, The Islamia University of Bahawalpur, University of the Punjab, Lahore, Government College University, Faisalabad, University of Sargodha and other higher education institutions. Students from these universities were direct beneficiaries of and exposed to recent trends in digital and Artificial Intelligence (AI) based learning.

Sampling Techniques

The researcher employed a non-probability, purposive sampling technique to identify participants that employed digital and AI based learning.

Sample size

A total of 268 participants took part in the study. Data were collected through an online questionnaire. The participants came from different fields of study and higher education institutions, providing a diverse sample for the analysis.

Data Collection

Data were collected by means of a predesigned, structured questionnaire. The survey measures Artificial Intelligence-Based Learning by adapting questions from research studies about Artificial Intelligence (AI) and other types of technology in learning. The survey measures Learning Engagement by adapting questions from research studies about the multiple dimensions of student engagement. The survey measures students' Cognitive Flexibility by adapting questions from a Cognitive Flexibility Scale. The survey measures students' Cognitive Flexibility by evaluating students' consideration of various ways of thinking or acting and their predisposition to modify their thinking or behavior. The survey evaluated students' Cognitive Flexibility by using similar types of questions in different ways to adapt to the field of study. The survey was initially designed in English and then converted to an online version by using Google Forms. The online survey was posted on various social networking sites and other online communication platforms used by students. Respondents were given an explanation about the study and were voluntary participants.

Data Analysis

The collected data was entered and structured in Microsoft Excel. The data was checked for errors and omissions. After the verification, the data was analyzed with the SPSS statistics software. To represent the data, descriptive statistics as means and standard deviations, as well as absolute and relative frequencies, have been calculated. The measurement scale's internal consistency was evaluated with Cronbach's Alpha. Pearson's product-moment correlation was used to analyze the relationships between Artificial Intelligence-based Education, Learning Engagement and Cognitive Flexibility. The prediction of Cognitive Flexibility by Artificial Intelligence-based Education was analyzed with a linear regression. Furthermore, Mediation analysis was used to evaluate if Learning Engagement was between Artificial Intelligence-based Education and Cognitive Flexibility. To evaluate group differences regarding the used demographic variables, independent-samples t-tests and one-way Analysis of Variance (ANOVA) could be used, and, in case of a significant result of the ANOVA, an appropriate post-hoc test was applied.

Table 1: Demographic Characteristics of Respondents (N = 268)

Demographic Variable	Category	Frequency (f)	Percentage (%)
Gender	Male	142	53.0
	Female	126	47.0
Age	18–22 years	108	40.3
	23–27 years	96	35.8
	28–32 years	44	16.4
	33 years and above	20	7.5

Demographic Variable	Category	Frequency (f)	Percentage (%)
Academic Level	Undergraduate	136	50.7
	Master's	98	36.6
	M.Phil./MS	28	10.4
	PhD	6	2.2
Field of Study	Social Sciences	72	26.9
	Education	63	23.5
	Business/Management	48	17.9
	Computer/IT	45	16.8
	Natural Sciences	40	14.9
University Type	Public	174	64.9
	Private	94	35.1

The results showed that 53.0 % of respondents were males, while the females accounted for 47.0 % of the respondents. The age bracket 18-22 years accounted for the largest (40.3 %) of the respondents, while the age bracket 23-27 years accounted for (35.8 %) of the respondents. The undergraduate students accounted for (50.7 %) of the respondents, while the Masters' students accounted for (36.6 %) of the respondents. The Social Sciences students accounted for (26.9 %) of the respondents, and the Education students accounted for (23.5 %) of the respondents. The Public Universities accounted for (64.9 %) of the respondents, while the Private Universities accounted for (35.1 %) of the respondents. Overall, the results indicated that the various age groups and levels of the education sector were represented in the sample.

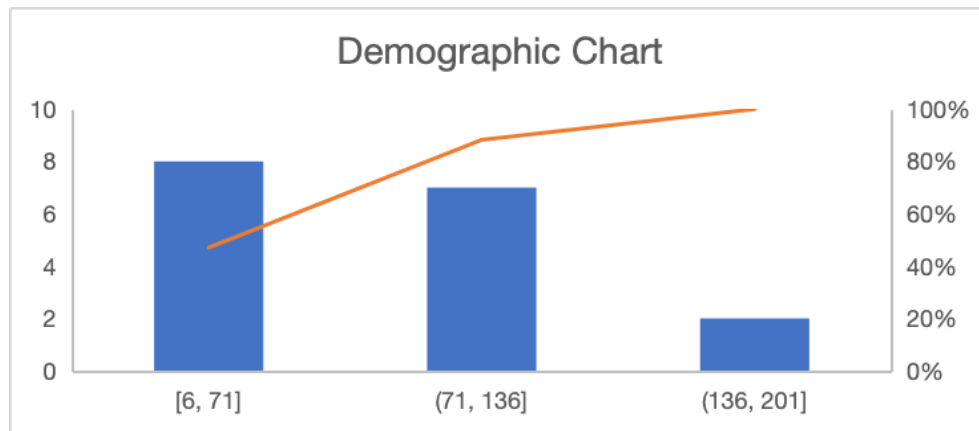


Fig. 2 Demographic characteristic of Respondents (N=268)

Table 2: Reliability Statistics and Descriptive Results of Study Variables (N = 268)

Variables	No. of Items	Cronbach's Alpha (α)	Mean	Std. Deviation
Artificial Intelligence-Supported Education	8	.912	3.81	0.69
Learning Engagement	9	.895	3.76	0.71
Cognitive Flexibility	8	.883	3.73	0.72

Reliability analysis of study variables indicated good to excellent internal consistency with Cronbach's alpha values from 0.883 to 0.912. Mean response values were in the range of 3.73 to 3.81. Standard deviation of responses was in the range of 0.69 to 0.72. It may be concluded that, measurement scales used in the study, have good level of reliability. Thus, further analysis of the data was undertaken.

Pearson Correlation Analysis

Table 3: Pearson Correlation Between Artificial Intelligence-Supported Education and Students' Cognitive Flexibility (N = 268)

Variables	1	2
1. Artificial Intelligence-Supported Education	1	.624**
2. Students' Cognitive Flexibility	.624**	1

$p < .01$ (2-tailed).

The results of the Pearson correlation analysis indicated a positive significant relationship between Artificial Intelligence-Supported Education and students' Cognitive Flexibility, $r = .624$, $p < .01$. Thus, students who noted the use of or interaction with AI-supported education and learning services indicated higher levels of cognitive flexibility. The nature of the relationship was positive and suggested that students' cognitive flexibility improved with the use of AI-integrated education.

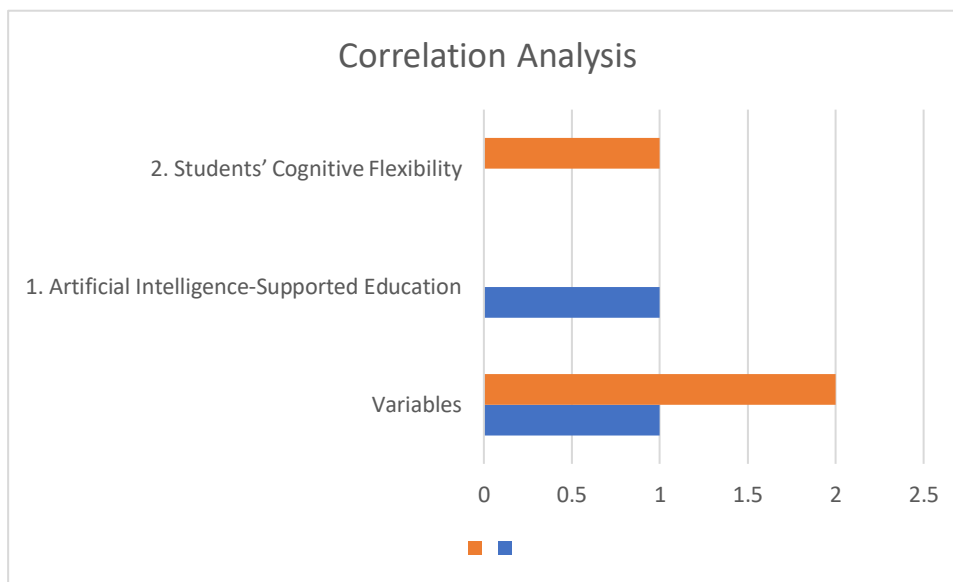


Fig. 3 Pearson Correlation Analysis

Table 4: Simple Linear Regression Predicting Students' Cognitive Flexibility from Artificial Intelligence-Supported Education (N = 268)

Predictor	B	SE	β	t	p
Constant	1.286	0.218	—	5.899	< .001
Artificial Intelligence-Supported Education	0.642	0.052	.624	12.346	< .001

Model Statistics	Value
R	.624
R ²	.390
Adjusted R ²	.388
F	152.42
p	< .001

$p < .01$ (2-tailed).

The results of the Pearson correlation analysis indicated a positive significant relationship between Artificial Intelligence-Supported Education and students' Cognitive Flexibility, $r = .624$, $p < .01$. Thus, students who noted the use of or interaction with AI-supported education and learning services indicated higher levels of cognitive flexibility. The nature of the relationship was positive and suggested that students' cognitive flexibility improved with the use of AI-integrated education.

Table 5: Mediating Role of Learning Engagement in the Relationship Between Artificial Intelligence-Supported Education and Students' Cognitive Flexibility (N = 268)

Effect	Effect (B)	BootSE	BootLLCI	BootULCI
Total effect of AI-Supported Education on Cognitive Flexibility	0.642	0.052	0.540	0.744
Direct effect of AI-Supported Education on Cognitive Flexibility	0.391	0.061	0.271	0.511
Indirect effect through Learning Engagement	0.251	0.043	0.170	0.340

According to the mediation analysis, Learning Engagement mediated the Artificial Intelligence-Supported Education and Cognitive Flexibility relationship. The indirect effect was estimated at 0.251. The 95% bootstrap confidence interval was between 0.170 and 0.340, therefore, it was concluded that the effect was zero. The results suggested that Engagement with AI-supported education helped enhance Cognitive Flexibility. The total effect of AI-based Education was 0.391. It can be concluded that Learning Engagement was a partial **mediator of the effect of Artificial Intelligence-based Education on Cognitive Flexibility**.

Table 6: Independent-Samples t-Test of Students' Cognitive Flexibility by Gender (N = 268)

Gender	n	Mean	Std. Deviation	t	p
Male	142	3.79	0.68	2.417	.016
Female	126	3.64	0.75		

The results of the independent-samples t-test on Cognitive Flexibility based on student's gender showed a statistically significant result, $t(266) = 2.417$, $p = .016$. On average, students explained Cognitive Flexibility at a level of $M = 3.79$ ($SD = 0.68$), and females at a level of $M = 3.64$ ($SD = 0.75$). Based on the results, the researchers supported their hypothesis that there is a difference in Cognitive Flexibility based on students' gender.

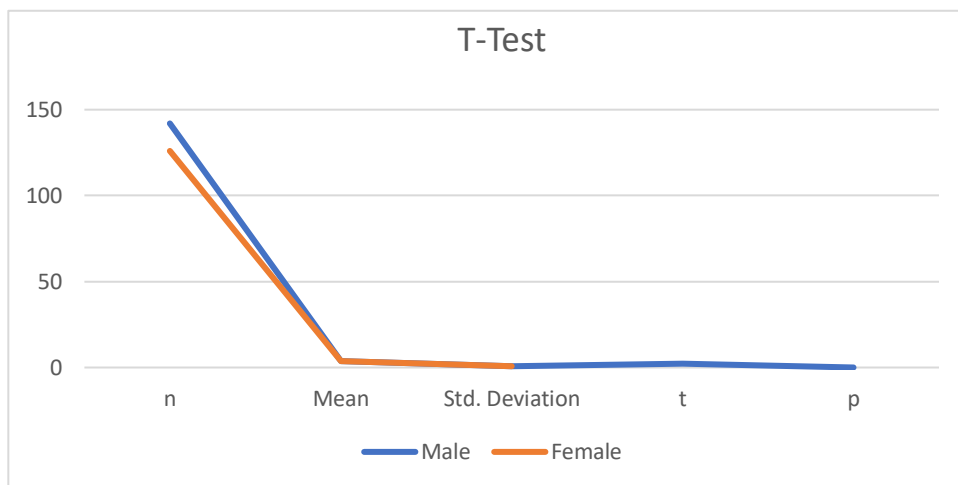


Fig. 4 Independent Samples t-Test of student's cognitive flexibility by Gender (N=268)

Table 7: One-Way Analysis of Variance of Students' Cognitive Flexibility by Age Group (N = 268)

Age Group	n	Mean	Std. Deviation
18-22 years	108	3.61	0.71
23-27 years	96	3.75	0.68
28-32 years	44	3.88	0.67
33 years and above	20	3.96	0.65
Total	268	3.73	0.72

One-Way ANOVA Summary for Students' Cognitive Flexibility by Age Group

Source	Sum of Squares	df	Mean Square	F	p
Between Groups	4.126	3	1.375	2.742	.043
Within Groups	132.291	264	0.501		
Total	136.417	267			

The results of the one-way ANOVA on students' data showed a significant difference in cognitive flexibility in the four age groups, $F(3, 264) = 2.742$, $p = .043$. Means indicated an increase in cognitive flexibility with higher age groups. Age group students of 18-22 had a mean of 3.61 and 33 and over had a mean of 3.96. Overall, the results showed that students' cognitive flexibility increased with older age groups, supporting hypothesis 5.

Learning Engagement by Academic Level

Academic Level	n	Mean	Std. Deviation
Undergraduate	136	3.67	0.72
Master's	98	3.82	0.68
M.Phil./MS	28	3.91	0.65
PhD	6	4.05	0.59
Total	268	3.76	0.71

One-Way ANOVA Summary for Learning Engagement by Academic Level

Source	Sum of Squares	df	Mean Square	F	p
Between Groups	3.684	3	1.228	2.492	.060
Within Groups	130.168	264	0.493		
Total	133.852	267			

The results of the one-way ANOVA on Learning Engagement based on academic levels showed that differences were not statistically significant ($F(3, 264) = 2.492$, $p = .060$). The mean level of Learning Engagement of PhD students was 4.05, followed by M.Phil./MS students (3.91), Master's students (3.82), and undergraduate students (3.67). The differences among the groups, however, were not statistically significant; therefore, the results did not support Hypothesis 6.

Discussion

This study investigated the relation between Artificial Intelligence (AI) in Education, Learning Engagement and Cognitive Flexibility. Results generally indicated a positive relationship between AI in Education and Cognitive Flexibility, and a positive Cognitive Flexibility forecast with regard to AI in Education. The results of the path analysis indicated that Learning Engagement positively mediated between AI in Education and Cognitive Flexibility. This means that the educational effects of AI may include, next to providing information and/or support in learning, an active engagement of the learners with AI in learning activities in such a way that learners become open to think and learn in various ways and adapt to learners' demands in different situations (Shukla, 2026).

The results of the present study are consistent with previous studies focused on the effects of the integration of interactive and adaptable AI in education. These studies have shown that when students work with interactive and adaptable AI, it has a positive effect on students' cognitive and metacognitive functions. For example, cognitive flexibility is an important aspect in the design of learning environments that are supported by AI (Faiz et al., 2026).

The regression analysis also showed that AI-Supported Education causes Cognitive Flexibility, and in a positive way, and therefore, implies a high degree of variation. The findings give evidence to the effects that AI in education positively influences students' cognitive flexibility in ways that differ from traditional teaching methods. Students' cognitive flexibility positively influenced by the integration of educational AI positively influences the student's capacity to modulate and shift their patterns of thoughts and behavior towards different strategies to achieve a particular task. The findings imply that educational AI has the potential positively to influence students' cognitive flexibility if used in the right way. The study also positively influenced Learning Engagement. This finding is also positively influenced by the integration of educational AI. The students reported that focusing on learning positively influenced their overall experience with the educational AI and engaged them. Overall, the educational AI influenced students' participation in a meaningful way, and therefore, positively influenced learning (Leonita et al., 2026).

From the mediation analysis it can be concluded that Cognitive Flexibility positively mediated the relationship between Educational AI and Teaching We found Learning Engagement partially mediated the relationship between AI-Supported Education and Cognitive Flexibility (Ertan & Esfer, 2026). The absence of the indirect effect in the bootstrap confidence interval implies AI-Supported Education positively affects Cognitive Flexibility through Learning Engagement. Further, the positive and significant direct effect of AI-Supported Education on Cognitive Flexibility suggests partial mediation. AI-Supported Education promotes Learning Engagement and consequently, Cognitive Flexibility. Thus, from the mediating effects of Learning Engagement, AI-supported education may help learners consider different viewpoints and possibility, learn and engage with differing emotional and behavioral dispositions, and reconsider academic concerns in a more flexible manner. Other studies show similarly positive effects of AI-Supported Education on learning outcomes and behavior. Engaging with AI-Supported Education positively affected students' critical thinking and communication skills.

Regarding Learning Engagement, the literature states that engagement in AI-supported learning is complex. A systematic review by (Javed et al., 2026), focused on the behavioral, cognitive and emotional engagement of participants in relation to the support provided by Artificial Intelligence (AI). Similarly, in a study by (Tianyue et al., 2026), participants reported that while engagement supported their learning, there were negative effects on participants' emotional and cognitive state. The present study contributes to the literature in establishing engagement as being related to cognitive flexibility. However, the authors of the present study position engagement as a process that supports the connection between AI-based learning and the cognitive restructuring of students.

The relationship between Learning Engagement and Cognitive Flexibility is strengthened by findings from the field of educational psychology. In a large-scale study of 670 Chinese undergraduates, (Alanazi & Alsaleh, 2026) demonstrated that cognitive flexibility and learning engagement are positively related to one another. Other elements of the researchers' model further supported the relationship of cognitive flexibility and learning engagement. This study adds to this body of research by establishing Learning Engagement as the connecting element between cognitive flexibility and AI-based learning.

The researchers also analyzed demographic data. The results showed that cognitive flexibility varied significantly based on respondents' gender and age. However, the level of learning engagement of the participants was similar regardless of their academic level (Namaziandost & Rezai, 2024).

The results suggest that cognitive features are likely to vary by demographic groups, and engagement is probably to be comparable across levels. These results are likely to be specific to the current population studied, and may not be broadly generalized. It is hoped that this research has added and enhanced understanding about AI-Supported Education and Learning in various elements,

particularly Cognitive Flexibility. Generally, the results of the study have positively framed AI-assisted Education and have demonstrated the importance of actively participating in the educational process. The results of the study indicate AI-assisted Education has a positive impact on Cognitive Flexibility. Positive results have been demonstrated, even though a substantial element of Learning Engagement still remained unexplained. Further, it is important to keep in mind that the net positive results of this study are dependent upon the quality, oversight, and design of AI in Education. The findings support active Learning and the positive effects of integrating AI to support Education. It may be that the active participation of learners in a guided and structured environment using AI, positively impacted Cognitive Flexibility.

Conclusion

This study found a positive relationship between the use of Artificial Intelligence (AI) in education and cognitive flexibility. Findings showed that the use of AI in education positively influences cognitive flexibility, and that cognitive flexibility was predictable by the use of AI in education. Further, this work showed that, in the context of an AI-supported learning experience, learning engagement positively influenced cognitive flexibility and thereby mediated the relationship between AI-supported education and cognitive flexibility. It thus appears that AI in education assists students in interacting with learning materials, considering varied ways of approaching learning, and in adjusting and adapting their thinking to learn more broadly and to respond to varied situations in classroom learning. The findings of this research also showed that the use of AI in education positively impacted cognitive flexibility, and that this relationship was partly mediated by learning engagement. Therefore, incorporating AI in education may positively impact cognitive flexibility of learners via varying other mediating mechanisms. The findings also showed that, in combining the use of AI and other interactive learning strategies in the classroom, educators may facilitate students' active participation, advanced thinking and learning in higher education.

Future Implications

Future research should examine how the use of Artificial Intelligence (AI) in education affects student engagement, cognitive flexibility, and other learning outcomes across different groups of students. Researchers can use different research designs, including experimental and longitudinal approaches, to gain a deeper understanding of these effects. Future studies may also explore whether these outcomes are influenced by the quality of students' interaction with AI, individual differences such as digital and critical literacy, motivation, and other relevant factors. Different approaches may include cultural and educational differences and various levels of education (i.e. primary, secondary, post-secondary). Mixed methods research to capture students' cognitive development and usage of AI in different contexts and for different educational purposes is necessary. Strengthening such research and developing best case scenarios to inspire active learning and cognitive flexibility would improve the field.

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