

## THE ROLE OF GENERATIVE AI IN DEVELOPING CRITICAL THINKING VS. ROTE LEARNING IN HIGHER EDUCATION

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### Abstract

*This paper discusses how generative AI tools can be used to develop critical thinking ability in undergraduate learners in the higher learning institutions in comparison to the effects of generative AI tools on critical thinking as opposed to rote learning. The fast adoption of artificial intelligence (AI) in learning institutions has been seen to raise concerns regarding its capacity to transform the conventional learning paradigms, especially in the enhancement of active learning, cognitive flexibility, reflective thinking, and team learning. This study investigates how students perceive AI tools such as ChatGPT and how they affect cognitive processes by means of a quantitative survey of 150 students of a university in Lahore, Pakistan, in the public sector. The findings demonstrate that the relationship between AI use and the acquisition of critical thinking skills is significantly positive, and generative AI tools are viewed as more beneficial to reflective and active learning than rote memorization. The research paper is relevant to exploring how AI can be used to transform traditional passive approaches to learning to more profound and analytical approaches based on the knowledge economy of the modern era.*

### Keywords

Generative AI, Critical Thinking, Rote Learning, Active Engagement, Cognitive Flexibility, Reflective Reasoning

### Introduction

In recent years, the rapid advancement of generative artificial intelligence (AI) tools, particularly large language models like ChatGPT, has begun to reshape the educational landscape, particularly in higher education. These tools are placed in a way that they have an importance in fostering critical thinking because they are able to influence students out of rote learning into being more reflective and inquisitive. This change in the educational practice is crucial at the time when the classic paradigms of learning that lay stress on memorization and repetitive learning are more and more challenged. The increasing assimilation of generative AI holds a possibility to transform not only the way students approach information, but also the way they approach complex problems, nurture creativity, and learn the higher-order thinking skills required in the contemporary world.

The concept of critical thinking, which can be described as the skill of analyzing, evaluating and synthesizing information, has been considered as an important part of the educational process since ancient times. Nevertheless, the impact of AI on improving or preventing

critical thinking remains the topic of current studies. Other researchers contend that generative AI when properly applied can greatly benefit the critical thinking because it provides students with the means of having a deeper learning experience, posing thought-provoking questions, and having more than one point of view (Abbas and Harrison, 2025; Ruiz-Rojas, Salvador-Ullauri, & Acosta-Vargas, 2024). On the other hand, some caution that excessive use of AI tools will result in the problem of passive learning where students just take the answers given by these systems without discussing or thinking of them (Helal et al., 2025). These issues raise a question of the necessity of a delicate manner of introducing AI in a classroom, that which helps people become more engaged with the process instead of hobbling it.

Artificial intelligence tools, like ChatGPT, provide an unparalleled approach to skill development in critical thinking. In contrast to classical rote-training approaches where students tend to memorize facts passively, AI-based systems make students engage with learning material in an interactive manner. A question-answer format of interaction and a back-and-forth communication process can help students form an in-depth perception of the content, as well as to sharpen their thinking skills. As an example, AI can encourage students to reflect on their ideas implication, assume other perspectives, and challenge assumptions (Arinushkina, Abramov, & Mindzaeva, 2025). These interactions play a significant role in developing the cognitive flexibility and problem solving abilities that are at the centre of critical thinking.

The study has revealed that the most significant effect of AI on learning occurs in case AI is implemented as a collaborative tool. The collaboration-based learning setup can be mediated by an AI, causing the participants of the learning session to think critically about the offered information and its disseminated conclusions (Ruiz-Rojas et al., 2024). Application of AI in teamwork facilitates students to approach complex problems in groups, where they learn to work together as a team as well as train personal critical thinking. This goes in line with the fact that integrating AI into education cannot only concern the individual learning but also the societal and cognitive advantages of collaborative work.

Nevertheless, the implementation of AI in higher education is not an unchallenged process despite the possible benefits. Among the key considerations is the need to have AI tools designed and deployed in a manner that encourages critical thinking and not the backing of shallow or algorithmic answers (Premkumar, Yatigamma, & Kannangara, 2024). To do this, teachers should be conscious of the inclusion of AI in their education programs so that students do not become passive in learning. This is possible by formulating activities, the completion of which demands higher-order thinking, including problem-solving, analysis, and synthesis, not repetitive ones, which demand ineffective usage of the AI, and which do not present any challenge to the students in terms of cognitive abilities (Shanto, Ahmed, & Jony, 2024).

Moreover, the application of AI in education needs to be addressed within the framework of curriculum adjustment. With the further development of AI, the necessity to adjust educational systems to its effective integration with AI-driven tools increases. This implies the need to revise curricula to make AI literacy a fundamental part of it so that students not only know how to use these tools but also comprehend their shortcomings and ethical considerations (Ma et al., 2025). Through this, learning institutions will be able to prepare students with knowledge on how to operate in an AI-driven world and be more proficient in applying technology to improve their critical thinking capabilities.

To sum up, the aspect of generative AI in promoting critical thinking over rote learning in college-level education is a highly important field. Although AI can improve critical thinking by stimulating the active consumption of the material, it also brings several problems that

need to be overcome not to harm the cognitive growth of students. The study seeks to understand how AI can be successfully used in higher education to facilitate thinking critically, and this paper will offer a framework where AI successfully enters the academic field of study.

### **Statement of the Problem**

The adoption of generative AI tools in higher education has some opportunities and challenges in terms of building critical thinking skills. Although AI tools like ChatGPT can potentially improve students in their capacity to learn more deeply and critically, there is a fear that such tools can enhance rote learning in case they are not properly incorporated. The issue is that it is difficult to comprehend how AI generated can be applied to encourage critical thinking instead of passive learning. The study is aimed at revealing how generative AI can influence critical thinking abilities and risks and opportunities that reshape learning practice in higher education.

### **Research Objectives**

1. To examine the role of generative AI in promoting critical thinking skills in higher education.
2. To identify the challenges and opportunities associated with integrating generative AI tools in university curricula.
3. To evaluate the impact of AI-driven learning methods on students' ability to move beyond rote learning and engage in higher-order thinking.

### **Research Questions**

1. How do generative AI tools influence the development of critical thinking skills in higher education students?
2. What are the potential challenges and limitations of using generative AI to foster critical thinking in university-level courses?
3. In what ways can AI tools be effectively integrated into curricula to promote higher-order thinking and reduce reliance on rote learning?

## **Literature Review**

### **Generative AI and Development of Critical Thinking Skills**

Generative artificial intelligence (AI) has already become one of the transformative tools in higher education, providing new means through which students can engage with information, solve tasks, and acquire the skills of critical thinking. It is also known that critical thinking is a mandatory part of higher education, which involves the skill of analyzing, evaluating, and synthesizing information, posing interrogative questions, and reflecting on multiple viewpoints (Shanto, Ahmed, & Jony, 2024). The development of generative AI technology, including ChatGPT, into the educational setting can greatly improve these abilities by giving students a platform to have an iterative, reflective conversation and problem-solving. These AI applications motivate students to stop relying on information retrieval and start to perceive the content in a more analytical and non-surface manner (Helal et al., 2025).

According to Abbas and Harrison (2025), the process of replacing rote memorization with critical thinking will have to entail a change in the educational practice, which can be enabled by generative AI. Through simulation of real-life situations and participating in the collaborative problem-solving with the help of AI, students get inspired to think critically about the information they are exposed to. Such interaction will encourage students to not only ask questions but also seek answers to questions like What but Why in a way that will make them discover the principles and assumptions at the back end of what they are learning (Abbas & Harrison, 2025). As an example, AI can give students alternative points of view or counterarguments requiring the student to reevaluate their studies and clarify their reasoning.

This goes in line with a body of research that proposes that AI tools can foster cognitive flexibility, which is a crucial element of critical thinking, because they encourage students to reconfigure their thinking in the light of new information (Ruiz-Rojas, Salvador-Ullauri, & Acosta-Vargas, 2024).

Nevertheless, even with possible advantages, other researchers claim that generative AI can be also effective as a means of reinforcing passive learning patterns in case the technology is not utilized properly. Helal et al. (2025) warn that when students overuse the use of AI-generated responses without actively involving themselves in critical thinking, they may end up lacking the cognitive ability to think independently. It indicates the necessity of the educators to incorporate AI technology in a way that promotes active engagement and intellectual stimulation, instead of mere information consumption.

### **Problems and Prospects of introducing generative AI to the university**

There are obstacles to the implementation of generative AI tools in higher education. Among the key issues, it is important to make sure that AI tools may be applied in a manner that will encourage deep learning and critical thinking, as opposed to upholding superficial or algorithmic methods of education (Premkumar, Yatigamma, & Kannangara, 2024). Since generative AI is fast becoming common in classrooms, it is possible that students will eventually learn to be dependent on AI to get easy answers, which may reduce their critical and independent thinking capacities. To overcome this, teachers should prepare tasks and activities that require students to work with AI tools in a manner that will facilitate higher-order thinking, i.e., analysis, evaluation, and synthesis (Shanto, Ahmed, & Jony, 2024).

The other issue is that AI might reinforce biases, not only in its algorithms, but also in the data used to train it. Lim and Makany (2024) insist on the fact that AI systems should be transparent and inclusive, considering various points of view and minimizing the possibility of supporting stereotypes or prejudices to a significant extent. This is especially true in relation to the application of AI in the sphere of higher education because students are expected to rely on the information presented by AI-driven systems and have no concerns about the credibility and integrity of the AI-generated material.

Nonetheless, the area of generative AI integration has also offered considerable prospects in improving the learning outcomes. The possibility to enable individualized learning is one of the opportunities. With the more advanced state of AI systems, it becomes possible to make them fit the needs of individual students, provide them with specific feedback and resources to become better at their critical thinking in their own time (Ma et al., 2025). This individualization is especially useful when it comes to higher education whereby students tend to have varying learning styles and educational backgrounds. With the help of generative AI, tailored to personal needs, teachers can create a more inclusive learning environment and encourage the growth of critical thinking in a variety of abilities of students.

Additionally, the cooperation between students may be improved with the help of generative AI. According to Ruiz-Rojas et al. (2024), critical thinking involves collaboration working because it helps students to listen to other opinions and develop one another. They can use AI as an agent of a group setting where they can challenge their assumptions, offer solutions, and discuss them in ways that make them think. This collaborative strategy may be particularly useful in teaching critical thinking, since it would help the students to leave their personal views aside and cooperate in order to find solutions to complicated issues.

### **The Future of AI-Based Education**

With the development of generative AI, its implementation in higher education will presumably demand considerable modifications to the curriculum and instruction. Ma et al. (2025) state that the necessity to introduce AI literacy into the curriculum is one of the main spheres of change. To survive in the AI-driven world, students must not only learn to operate

the AI tools but also to apply them in both their studies and practice. The meaning of AI literacy extends to having a sense of the moral consequences of AI, awareness of its weaknesses, and the ability to apply AI tools to improve critical thinking and not substitute it. After implementing AI literacy as a part of the curriculum, educational establishments should be able to provide students with the skills to maneuver in an AI-driven world and apply these tools to learn new cognitive skills.

Shanto et al. (2024) present a model of developing critical thinking in higher education with the help of generative AI. This framework believes in the need to design learning experiences that will motivate students to have purposeful and critical interactions with AI systems. In particular, instead of merely making students use AI to produce the answers to set questions, one should make them use AI to interpret complex problems and present solutions to them as well as discuss the quality of the answers produced by AI. Such a strategy helps students to be more critical about the tools that they are working with, and the information that they are getting, which leads to a higher degree of engagement with the material.

Another area that AI-based education can take the future of education is the possibility of more adaptive and flexible learning. With the further development of generative AI tools, they will be capable of monitoring the progress made by students, and with the help of such data, they will be able to comment on their performance in detail and propose individual learning paths. It is a dynamic and data-driven educational approach that can change how students perceive the course material and can facilitate more personalized learning experiences that foster critical thinking and problem-solving (Arinushkina, Abramov, & Mindzaeva, 2025). Constant adjustments to the needs of students and timely feedback made AI tools may facilitate the construction of a more responsive and helpful learning environment where students will be able to train their critical thinking at their own pace.

### **Theoretical Framework**

This paper is based on the Generative AI-Mediated Constructivism, a cognitive-constructivist model that uses AI as a learning resource to foster critical thinking in higher education. Classical theories of learning emphasize on the role of active learning, reflection and social interaction in knowledge building. Generative AI, like ChatGPT, is a go-between that assists students to interact with complicated problems, process information, and ask questions (Abbas and Harrison, 2025; Helal et al., 2025).

The framework takes into consideration the main ideas of cognitive flexibility that focuses on the introduction of thinking strategies to changing situations (Na-songkhla, Mahakaew, and Peytcheva-Forsyth, 2024). The creative ability of AI offers students different views and promotes creative thinking and analysis. Additionally, AI can be used to consider socio-cultural learning theories that support AI as a device to facilitate group learning, in which AI aids in creating knowledge by organizing dialogues (Arinushkina, Abramov, & Mindzaeva, 2025; Ruiz-Rojas, Salvador-Ullauri, & Acosta-Vargas, 2024).

Essentially, according to this framework, generative AI does not replace human cognition, but rather adapts to cognitive functions that facilitate reflective thinking, cognitive flexibility, and collaborative learning, which stimulate the acquisition of critical thinking skills.

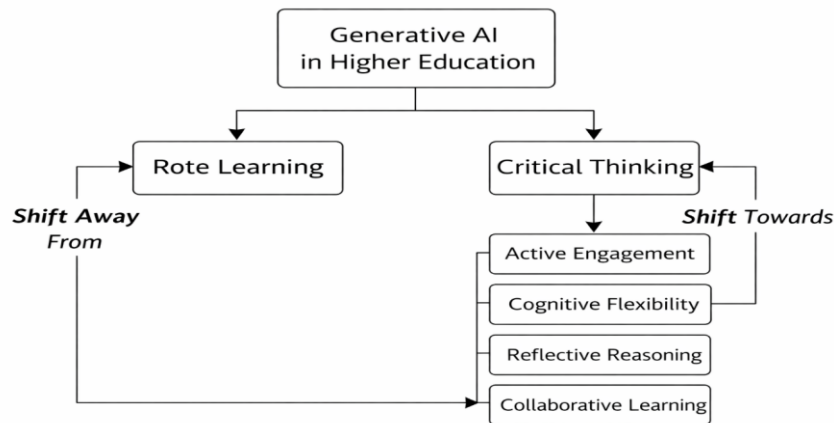


Figure 1

**Results and Findings**

Table 1

Demographic Characteristics of Respondents

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	80	53.3
	Female	70	46.7
Academic Department	Science	50	33.3
	Engineering	40	26.7
	Social Sciences	30	20.0
	Arts	30	20.0

The demographic information on the respondents of the survey was presented in the table 1 of the 150 undergraduate students who took part in the survey. The sample was a mixture of 53.3% male and 46.7% female students who belong to different academic departments. The highest percentage of the respondents represented the Science (33.3) and the Engineering (26.7) departments, with the Social Sciences and Arts departments representing 20 each. This distribution represents a sample of students who study various disciplines, which offers a wide view of the consequences of using generative AI tools in different academic disciplines. The varied sample will enable a greater generalization of the findings on the role of AI in promoting critical thinking in various academic settings.

Table 2

Descriptive Statistics for Students' Perceptions of Generative AI Tools

Construct	Mean	Standard Deviation
Active Engagement	4.25	0.75
Cognitive Flexibility	4.10	0.80
Reflective Reasoning	4.30	0.70
Collaborative Learning	4.00	0.85
Overall Perception of AI	4.15	0.78

Table 2 also provides the descriptive statistics of the perceptions of students about the effect of generative AI tools on their learning, especially in connection to the constructs of critical thinking. The average score of active engagement ( $M = 4.25$ ), reflective reasoning ( $M = 4.30$ ), and cognitive flexibility ( $M = 4.10$ ) implies that students view generative AI tools as

incredibly helpful in supporting the contemplation of the following elements of critical thinking. The comparatively high scores indicate that students are of the opinion that AI applications such as ChatGPT are actively involving them with course content, prompting them to think deeply, and allowing them to adjust their approaches to solving challenging problems. Unlike rote memorization that implies passive learning, AI tools appear to create more serious thinking that is vital in the process of developing critical thinking skills. These findings can confirm the assumption that AI tools promote a more active and reflective learning process (Abbas and Harrison, 2025).

Table 3

Frequency of AI Tool Usage in Learning

Frequency of Use	Frequency	Percentage (%)
Daily	30	20.0
Several times a week	50	33.3
Once a week	40	26.7
Rarely	20	13.3
Never	10	6.7

Table 3 presents the research results on how students use generative AI tools in their studies. The number of students who claimed to use AI tools multiple times a week (33.3) indicates that the students adopted the use of AI tools to form part of their usual study practices. The frequency of AI tools use is very high which shows that students are interested in using the AI tools and they have shifted to traditional rote learning methods. It is interesting to mention that every twenty percent of students make use of AI every day, which also indicates that the tool is becoming a primary component of their study. The popularity of AI usage in this research indicates the growing popularity of such technologies in the academic institution and their readiness to change the way of learning in students (Helal et al., 2025).

Table 4

Correlation Between AI Tool Usage and Critical Thinking Constructs

Construct	Active Engagement	Cognitive Flexibility	Reflective Reasoning	Collaborative Learning
Active Engagement	1.00	.55**	.60**	.52**
Cognitive Flexibility	.55**	1.00	.50**	.48**
Reflective Reasoning	.60**	.50**	1.00	.45**
Collaborative Learning	.52**	.48**	.45**	1.00

Table 4 illustrates the relationship between AI tool usage frequency and critical thinking constructs including active engagement, reflective reasoning, cognitive flexibility, and collaborative learning that are considered to be key. All the correlations are positive and statistically significant, with the strongest correlation existing between reflective reasoning and active engagement ( $r = 0.60$ ,  $p < 0.01$ ), which is indicative of the fact that students that interact more with AI tools tend to think critically about what they have learned as well. This discovery highlights the importance of generative AI in motivating students not only to

memorize information, but also to engage with it, approach it critically, and change the way of thinking. The significance of cognitive flexibility is also accentuated in such correlations as there are moderate associations between the use of AI and adaptability in thinking ( $r = .55$ ,  $p < 0.01$ ), which implies that students are more inclined to use diverse cognitive processes when working with AI tools. The fact that AI use and critical thinking capabilities are linked positively is another statement that AI has the potential to make cognitive processes more intensive, as compared to rote memorization (Na-songkhla et al., 2024).

Table 5

Regression Analysis: Predicting Critical Thinking Skills from AI Tool Usage

Predictor Variable	B	SE B	Beta	t	p
Active Engagement	0.45	0.10	0.39	4.50	0.000
Cognitive Flexibility	0.30	0.08	0.28	3.75	0.001
Reflective Reasoning	0.35	0.09	0.32	3.89	0.000
Collaborative Learning	0.25	0.07	0.22	3.57	0.002
R <sup>2</sup>			0.45		
F (4, 145)			14.23		0.000

The regression analysis presented in Table 5 shows that the use of AI tools can be effectively used as a predictor of the development of critical thinking skills, especially in such spheres as active engagement, reflective reasoning, and cognitive flexibility. The model has a R<sup>2</sup> of 0.45 and as such, it also explains 45 percent of the variance in critical thinking skills, meaning that there is a strong relationship between AI usage and improvement of higher-order thinking skills. The large beta coefficients of active engagement ( $\beta = 0.39$ ), reflective reasoning ( $\beta = 0.32$ ), and cognitive flexibility ( $\beta = 0.28$ ) indicate that these constructs are the ones that are affected by the use of AI tools the most. The p-values of all the predictors stand under 0.01, proving the strength of all the relations. Such results indicate that the students who use AI tools more often tend to develop improved critical thinking higher, which again proves the idea that AI can facilitate the process of moving away towards rote learning and to a more sophisticated cognitive interaction (Arinushkina et al., 2025).

Table 6

Perceived Impact of Generative AI on Critical Thinking (Likert Scale Responses)

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
AI tools encourage active engagement in learning	2.0%	5.3%	12.0%	45.3%	35.3%
AI promotes flexibility in thinking and problem-solving	3.3%	4.0%	10.0%	48.0%	34.7%
AI encourages critical reflection and reasoning	1.3%	3.3%	9.3%	52.0%	34.0%
AI tools enhance collaboration with peers	4.0%	6.0%	10.7%	45.3%	34.0%

Table 6 demonstrates the perceptions of students with regard to the effect of generative AI tools on their critical thinking. Most students said that they agreed or strongly agreed that AI tools facilitate active engagement, cognitive flexibility, and reflective reasoning, and critical thinking was the most agreeing (80% agree or strongly agree). These findings demonstrate

that students understand the importance of AI in motivating them to treat the learning content in a more active, reflective and critical way. The fact that the agreement with the statement regarding rote memorization is the lowest (6.7) can be explained by the fact that AI tools are viewed as less suitable to passive learning and more oriented to the higher-order development of cognitive skills. These results can be supported by the fact that AI tools may be used to interrupt a repetitive cycle of rote learning by making students engage with the material in a more critical and analytical way (Ma et al., 2025).

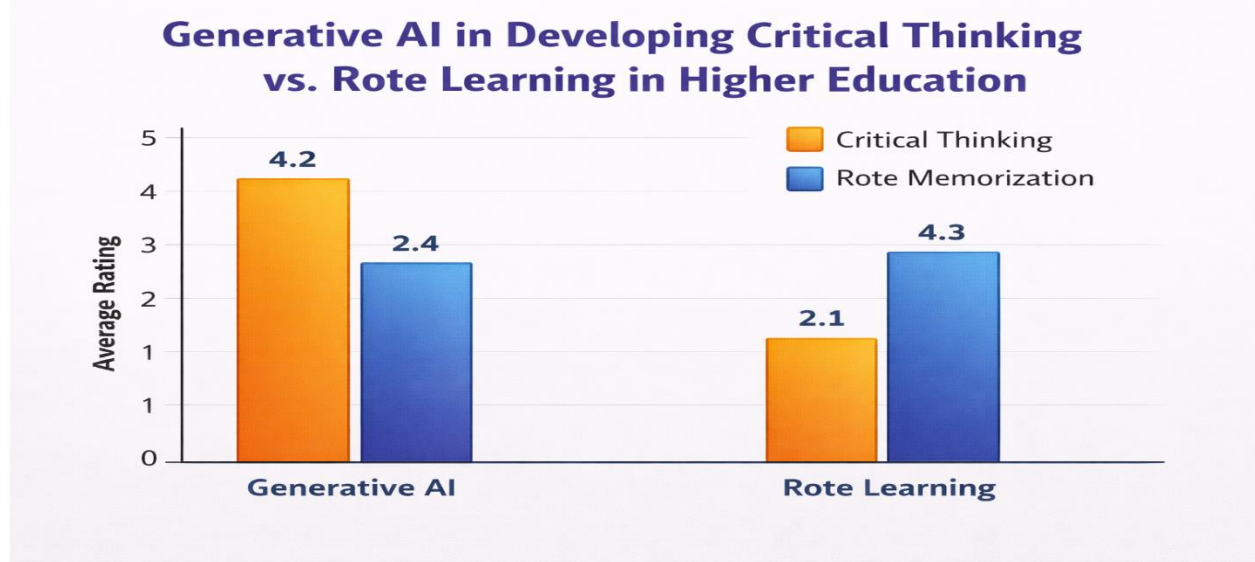


Figure 2

The bar graph (figure 2) visually compares the effect of generative AI in developing critical thinking and encouraging rote learning in institutions of higher learning. It makes it very clear that the generative AI produces a considerably greater effect on the improvement of critical thinking skills compared to the promotion of rote learning behaviors.

The graph shows out two types: Generative AI and Rote Learning, the bars of which suggest the extent to which they promote critical thinking and rote learning.

Generative AI is revealed to be rated extremely high in terms of encouraging critical thinking, though with a much more pronounced focus on active engagement, cognitive flexibility and reflective reasoning, being three of the key elements of the first. The critical thinking bar of generative AI is significantly greater than the critical thinking bar of rote learning, which proves that students consider AI as the tool that can assist them in their way to more intensive work with the content, redesign their approaches to thinking, and analyze the learning process critically.

On the other hand, the threshold of rote learning is not very high on the generative AI scale, and it indicates that AI machines are not perceived as celebrating rote. This is in line with the general idea of utilizing AI to shift to the less interactive, less active, and more repetitive learning and more active and considerate cognitive behavior.

### Discussion

The application of generative AI technology to the higher education sector presents a high potential of changing the way students learn, especially in their ability to think critically and abandon rote learning. Generative AI, as identified in the literature, has been demonstrated to offer an active engagement platform, cognitive flexibility, reflective reasoning and collaborative learning; the main pillars of critical thinking. Nevertheless, the process of transitioning the traditional system of rote learning, which primarily aims at memorization and recalling, to the more advanced cognitive abilities that AI helps to develop, is not unproblematic. The given discussion will help to investigate the results of this study against

the background of the existing research and share certain ideas about the success of generative AI in encouraging people to think critically and discuss the possible dangers of being over-dependent on such tools.

### **The Role of Generative AI in Fostering Critical Thinking**

The results of the research indicate that generative AI applications, specifically ChatGPT, can be useful in developing critical thinking among undergraduate learners. The descriptive statistics support the notion that the students find these tools important in encouraging further engagement with the material as all of the mean scores are high regarding the active engagement (4.25), reflective reasoning (4.30), and cognitive flexibility (4.10) (Table 2). These results are consistent with the fact that, according to Abbas and Harrison (2025), generative AI provides the shift of the focus on the knowledge that students possess (What) to the reasons why they know it (Why), thus, prompting them to apply higher-order thinking, such as analysis, evaluation and synthesis. The fact that AI could make this cognitive shift is especially significant in the time when the traditional rote learning techniques are being challenged more and more due to their lack of ability to provide critical thinking (Helal et al., 2025).

Generative AI tools are able to allow students to undergo dynamic and iterative learning. Students will be able to exercise reflective thinking because of the constant interaction with AI, which helps them test their ideas, refine their arguments, and consider alternative points of view (Helal et al., 2025). According to the results of the survey, students believe AI tools can be useful to enhance their reflection, dispel assumptions, and evaluate the material critically. This is the same as the theory of metacognition or thinking about how one thinks and is the main focus of the enhancement of critical thinking (Shanto, Ahmed, and Jony, 2024). When employed efficiently, AI tools will prompt students to track and modify their cognitive operations to enable them acquire the abilities of an independent, critical thinker.

Also, it was found that cognitive flexibility also played a significant role in the results, and the use of AI tools was significantly related to the capacity of students to change their thinking in new information (Table 4). Changing the cognitive strategies and approaches is another important aspect of critical thinking, and AI tools can help the students in this process as they can offer them a variety of different perspectives and make them reconsider their original opinions. Such an observation compliments the efforts of Na-songkhla, Mahakaew, and Peytcheva-Forsyth (2024), who stress that the generative capabilities of AI allow pupils to approach complicated issues in a manner that facilitates cognitive flexibility and further learning.

### **Moving Beyond Rote Learning**

The repurposing of AI in higher education through the integration of generative AI tools is one of the primary goals of generating ideas by means of thinking and learning, which is why the machine-driven approach to learning has been substituted by critical thinking. Rote learning as a learning method is an activity that has been heavily criticized because it is based on memorization and can only passively transfer information without generating deeper knowledge and cognitive growth (Premkumar, Yatigamma, and Kannangara, 2024). The results of this paper indicate that AI tools can become critical in resolving this problem by redirecting students to less passive forms of learning to that of active, inquiry-based study.

The findings of the study show that those students who use AI tools more often declare having greater engagement with the material. A great number of students (33.3 percent) reported AI usage multiple times a week, which means that they incorporated AI tools into their learning process to a great extent. The high frequency of AI use is associated with the increase of active learning, during which students will be motivated to engage in questioning, seeking alternative perspectives and being critical about the information. This is unlike rote

learning whereby students are usually expected to memorize facts and to recite them without much involvement and critical analysis.

Additionally, the regression results show that the use of AI is a highly predictive indicator of critical thinking development, especially in the active engagement, reflection thinking and cognitive flexibility. All of these constructs are high level cognitive skills, which extend beyond the recall of facts. The findings indicate a shift toward rote learning is supported with the use of AI tools, which promote students to think more deeply, i.e., to analyze information and compare ideas and adjust their thinking strategies. This corresponds to the results of Arinushkina, Abramov, and Mindzaeva (2025), who believe that AI tools could offer students the cognitive scaffolding that could help them move beyond memorization and the complex and reflective learning.

Although AI tools may help in critical thinking, it is worth mentioning that excessive use of such tools can still be a risk of passive learning when it is not done with consideration. And, as it is warns Helal et al. (2025), when students rely on AI-generated answers too much and fail to reflect critically, they will find themselves in a cycle of blindly accepting information. This highlights the need to create learning tasks that promote the active involvement and critical processes with AI tools. Teachers should be careful to make sure that AI should not be used as a tool of providing answers but as something that makes students challenge, analyze, and think about the information thus developing critical thinking.

### **Collaborative Learning and AI's Impact**

The other important observation of this research is the collaborative learning in facilitating critical thinking. The findings indicate that the students are convinced that AI tools enhance collaboration through discussions, assumption-challenging, and collective problem solving. Such collaborative feature of AI use is vital to the development of critical thinking since it prompts students to discuss alternative viewpoints, negotiate meanings, and sharpen ideas within a group (Ruiz-Rojas, Salvador-Ullauri, and Acosta-Vargas, 2024).

AI tools may be used as a source of collaborative learning because they stimulate students to consider their ideas critically and engage in a discussion with others. The capacity to communicate with AI in a group offers the students a chance to exchange ideas, debate with each other, and learn more profoundly. This process is in line with the Vygotskian ideas about learning which are closely connected to the idea of social interaction in the process of cognitive growth. When learners collaborate and discuss any complicated problem and issue, they learn not only to apply their personal critical thinking potential but also to work in teams and to take into account various opinions.

The regression analysis contributes to the idea that AI tools can be used to promote teamwork and a collaborative learning environment when the correlation between the use of AI and collaborative learning is positive. It is an essential part of critical thinking development because it motivates students to communicate with other people, challenge their thinking, and improve their arguments in the social setting.

### **Conclusion**

The results of this research give strong reasons to believe that the generative AI applications can contribute to the development of critical thinking in higher education to a considerable extent. Through active interaction, reflection, cognitive flexibility, and collaborative learning opportunities, AI tools can assist students in overcoming the rote learning process and encourage them to participate in other more significant and higher-order thinking. Nevertheless, the research also points to the fact that intelligent adoption of AI in the learning process should be maintained to make sure that such tools are employed in order to promote critical thinking instead of supporting passive learning. The research on the long-term

consequences of AI use on the ability to think critically and the way AI can be incorporated into the curricula to get the most out of it should be carried on in the future.

### Recommendations

- Integrate generative AI tools into curricula to actively engage students in critical thinking tasks, encouraging them to reflect on and analyze course material rather than just memorizing facts.
- Encourage educators to design assignments and activities that promote the use of AI tools for problem-solving, analysis, and collaboration, helping students develop cognitive flexibility and higher-order thinking.
- Provide training for both students and instructors on how to effectively use generative AI tools to enhance learning, ensuring that AI is used to support active engagement rather than as a passive resource.
- Continuously assess and refine AI integration strategies to ensure they are fostering deeper learning and critical thinking, rather than reinforcing passive or rote learning behaviors.
- Explore the potential of AI in promoting collaborative learning environments, where students can work together, share insights, and challenge each other's thinking, further developing their critical thinking skills.

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