



OVERDEPENDENCE ON AI SUPPORTED LEARNING AND CRITICAL THINKING: INVESTIGATING OPPORTUNITIES AND RISKS IN MODERN EDUCATION AT HIGHER EDUCATIONAL LEVEL

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Abstract

This research examines how AI-based learning resources can help learners develop a critical thinking skill in the context of higher education, both as an opportunity and a potential danger of overreliance. This research is aimed at evaluating the role of AI based learning on critical thinking skills in students concerning the proportions of potential disadvantages and the positive effects of AI tools. The participants were separated into two groups, including those who used AI-supported learning tools and those who did not. The sample of the study was extracted using multistage sampling approach in which 150 students were randomly selected at first stage. At second stage these participants were divided in to two groups (75 in each group) using convenient sampling technique to identify students using AI too and student who did not use. The data were collected using a specially developed critical thinking test in multiple choice as well as performance-based formats, based on Watson-Glaser Critical Thinking Appraisal (WGCTA).

Descriptive statistics, paired t-tests, and independent t-tests were applied in order to compare the critical thinking scores of the two groups and determine the relationship between exploring AI tools and cognitive performance. These results showed that AI-tool users have improved critical thinking scores by a significant margin, 51.5 (SD = 6.3) to 68.0 (SD = 5.0) ($t = 8.72, p < 0.05$), and the control group did not significantly improve in critical thinking scores.

Nevertheless, risks of being over dependent on AI tools were also noted in the study as it was observed that students had to engage into frequent use of AI tools which led to cognitive offloading where students had to rely less on free-thinking to solve their independent problems. The correlation test ($r = 0.56, p < 0.05$) indicated that the excessive use of AI tools could result in a lack of critical thinking and the use of superficial method of learning. This explains why it is necessary to combine the introduction of AI tools with the classic teaching method to encourage critical thinking and metacognition. Other ethical concerns like fair access to AI devices and possible bias within the AI algorithms were also addressed, and a reasonable and conscious approach towards the use of AI in learning was highlighted.

Keywords: AI-Assisted Learning, Critical Thinking Skills, Cognitive Offloading, Overdependence, Higher Education, Educational Technology.

1. Introduction

Artificial Intelligence (AI), which offers personalized learning and responsive education is one of the new technologies that have revolutionized the educational process at extremely high rates. AI applications



that can be dynamically adapted to the needs of individual learners to provide them with a personalized help include intelligent tutoring systems and automated feedback systems, which is hard to accomplish in a traditional learning setting (Baker et al., 2021; Woolf, 2020). Nevertheless, even though AI can be involved in the efficiency of the learning process, the issue of its influence on the process of acquiring critical thinking skills has been raised. Other researchers believe AI can help people to learn, and therefore, it has an opportunity to decrease the chances of students to think reflexively, and it is by this means that one will be able to learn the ability to think critically (Selwyn, 2020; Jones et al., 2023). As a recent report indicates, AI generative tools may be exposed to over-simplification of the hard reasoning process, and thus, the motivation to create a solution independently may be decreased, which is one of the complications of the critical thinking issue (Kim and Morrison, 2026).

Critical thinking is a fundamental mental ability that assists students to evaluate, analyse, and synthesize information as well as be the main focus of academic achievements and decision-making. Bloom taxonomy describes the significance of higher-order thinking in the cognitive growth (Facione, 2020). Nevertheless, the issues with AI in education also emphasize that it is likely to substitute the key cognitive functions that are needed to develop these high-level skills. The example in point is that the likelihood of receiving the immediate answers with the assistance of the AI can decrease the interest of the students towards the problem solving and problem analysis (Shute and Hansen, 2021; Wang et al., 2022). The recent research has indicated that the students who use AI devices the most show worse performance in evaluative thinking than those who have more reflective and self-directed learning (Gonzalez and Harper, 2025).

The potential and possible dependency of AI education is enormous and reaches the lack of cognitive activity. The assistance of AI in learning may offer timely feedback and adjust to the level of understanding of the students to offer a personalized learning experience to them (Hsin and Cigas, 2021; Pane et al., 2020). Such systems have the ability to improve the engagement of students since they can scaffold complex activities and provide individual learning that can be useful to students that might have difficulties with standard teaching approaches. However, the possibility of critical thinking can be diminished against his or her will due to the excess use of AI tools. The AI systems will only increase the superficial communication, unless effectively incorporated, and thus will not force people to think deeper and treat the issue (Rao and Stein, 2026). Therefore, AI can contribute to learning improvement, but it should be incorporated in a considered way to prevent the decrease of cognitive growth.

Cognitive offloading is one of the major problems of AI-assisted learning. This is called outsourcing cognitive processes to the outside devices that result in both a decrease in cognitive load and the possible damage to the formation of more critical thinking (Sweller et al., 2021; Park et al., 2024). The use of AI in attempts to solve issues annul the activities that contribute to the formation of original thoughts and testing and proving hypothesis (Azevedo et al., 2020). This high dependency on AI to give instant feedback and responses can result in lesser active thought among the students. According to the findings of one recent research study, the high-frequency use of the generative AI tools correlates with poorer performance in the critical thinking tests and this means that AI addiction may result in the development of lesser cognitive skills (Liu and Martinez, 2025).

The Cognitive Load Theory (Sweller et al., 2021) which states that human cognitive capacity is limited can explain cognitive implications of the AI in education. Extraneous cognitive load can be successfully reduced with the assistance of AI in order to make students focus on their learning activities. Nonetheless, excessive application of AI can cause cognitive offloading, and the necessity to make students think more profoundly is lower. Besides, AI feedback may be of no help in the self-regulation or metacognition that is needed in the growth of a set of critical thinking skills, but it can facilitate learning (Flavell, 2021). The recent research suggests that the lack of adaptive self-regulatory hints prevents AI systems to prompt the formation of metacognitive abilities that will enable the executive control process and the emergence of the required cognitive processes (Singh and Zhao, 2026).

The application of AI in learning tests brings the question of whether AI can assess critical thinking. The evaluation of the higher-order cognitive skills has possibly not been well evaluated using the traditional evaluation techniques that involve memorization. The automation of most of the cognitive processes of the AI



may cause confusion between the actual learning process and answers to the questions provided by the AI to the students (Bennett, 2021). Besides this, AI-enhanced tests can also be used in the formation of the shallow learning strategies such as the efficiency orientation and the insufficiency of engagement with the content (Johnson et al., 2025). Modern studies suggest that multi-stage tests should be used in which the students are expected to justify, criticism, and refine their answers due to the fact that the tests are more suitable in testing critical thinking (Martins et al., 2025).

The key factors in incorporating AI in education are equity and ethical issues. Digital divide implies that AI technologies cannot be used by all students, and they also may cause the further rise of inequalities in the educational process (Eynon and Helsper, 2021). In addition, AI tools are also prone to biases based on the information they are trained on and can have unfair results on the marginalized communities (O'Neil, 2020). Another 2026 article also examines the ability of AI to reproduce such inequalities because predictive analytics have the potential to influence educational opportunities in a way that would benefit some learners more than it would benefit others (Evans and Lee, 2026). Teachers and policymakers should ensure that AI tools are applied equitably and in a transparent manner that will promote equal access to quality learning opportunities that would enable the growth of critical thinking.

Although AI can be applied in education, the studies on the application of AI to its potential in shaping critical thinking across time are wide gaps. The majority of the studies that are available concentrate on the short-term results such as the test scores or the engagement without considering the long-term interaction with AI effects on cognitive development (Pane et al., 2020). The longitudinal study will be required to evaluate the effects of AI on critical thinking, problem-solving, and independent learning (Pillai et al., 2024). Besides, the integration of AI-supported learning with the cognitive science theories is not yet developed to the full extent, and we will not know about the long-term result of AI on skills of critical thinking in the future (Mohiuddin, 2026; 2025, Torrance et al., 2025). These loopholes will be filled to ensure the AI application in education is a more holistic approach where technology will be employed to enhance, and not to oppress, the growth of critical thinking.

Statement of Problem

The introduction of Artificial Intelligence (AI) to education has brought about both a great opportunity and a challenge, especially in regards to the acquisition of critical thinking. On the one hand, AI tools provide individualized learning, feedback in real-time, and adaptive learning environments and can meet the needs of individual students, which may increase student engagement and allow them to understand the material at a deeper level (Baker and Siemens, 2020). Such tools may offer highly personalized assistance, which cultivates creativity and problem-solving abilities by making students approach intricate activities in active, interactive forms (Hsin and Cigas, 2021). Nevertheless, conversely, the growing use of AI in the educational field poses the risk of the loss of critical thinking skills. With the increased sophistication of AI systems, students might start to rely on AI too much, which means that students do not have to engage their brains in the process of problem-solving, analysis, and evaluation (Selwyn, 2020; Jones et al., 2023). Such excessive reliance on AI can lead to cognitive offloading in which students lose interest in deep thinking and reflection, which are the same skills that one requires to reason and make decisions independently. Thus, although AI can be used to improve learning experiences, there is also a risk of making sure that its application will not interfere with the process of developing the ability to think critically, and without it, academic and professional success are impossible.

Objectives of the Study

1. To investigate the role of AI-assisted learning has an impact on developing critical thinking skills at higher education level.
2. To determine the possible threats and risks of the overuse of AI in educational practices at higher education level.

Research Questions of the Study

1. How AI-assisted learning can play an effective role in developing critical thinking skills at higher education level?



2. What are the possible threats and risks of the overuse of AI in educational practices at higher education level?

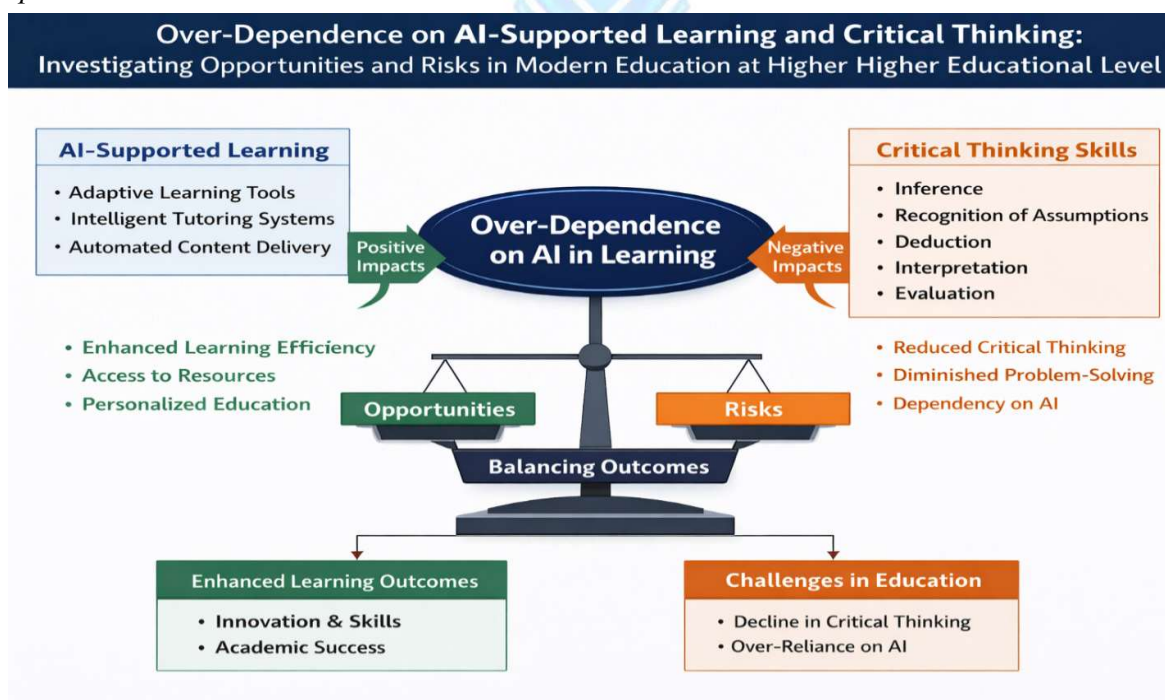
Significance of the Study

The study is also very much important because it explores the role Artificial Intelligence (AI) plays in education, especially its contribution to the process of critical thinking, which is a key part of cognitive development and academic performance. With the continued introduction of AI technologies into education, it is of utmost importance to comprehend the potential opportunities, as well as the possible dangers of using AI technologies, so as to make use of them appropriately. This study can be considered how AI can be used to improve individualized learning experiences, inspire creativity, and develop problem-solving abilities as well as consider the issue of cognitive offloading and the possibility of undermining the capacity of students to think deeply and reflectively. Moreover, discussing the equilibrium between the capacity of AI to automatize the process of learning and the necessity of students to retain control over the cognitive process, the study is expected to provide practical suggestions to educators, curriculum developers, and policymakers. The results can be add to the current discussion of the ethical implementation of AI into the classroom, which may not only be effective but also help to preserve intellectual autonomy and critical thinking. The insights of the current study could be invaluable in informing future educational systems that are more focused on equal opportunity, protection of cognitive growth, and use of AI technologies as an augmentation tool of human intelligence in the learning process, instead of a replacement. Through these complex challenges, the research will provide a holistic approach to the responsible use of AI in education so that it could continue to be a driver of education and not an agent of intellectual addiction.

Conceptual Framework

Figure 1

Conceptual Framework



Theoretical Framework

The Cognitive Load Theory (CLT) introduced by Sweller et al. (2011) can be used as a necessary approach to figuring out the effect of AI tools on cognitive engagement and critical thought in learning settings. CLT posits that learning is most efficient in cases of efficient management of cognitive resources, and AI can help in achieving that by certifying extraneous cognitive load. Intelligent tutoring systems and



adaptive learning systems are examples of AI that can optimize the learning process of students, making the material presented to them personalized and thereby reducing superfluous cognitive load and allowing the learner to devote themselves to more challenging tasks (Sweller et al., 2021). Nonetheless, excessive use of AI in learning may cause cognitive offloading when students excessively use the AI to complete cognitive processes and minimal effort in engaging in activities related to critical thinking where they need to analyse, evaluate, and think independently (Zhang and Wang, 2023). As CLT suggests, although simple tasks can be more efficient and effective with the help of AI, one must make sure that it does not substitute the intellectual input necessary to achieve deeper thinking, which, in its turn, is necessary to learn how to think critically (Sweller et al., 2021). According to Flavell (2021), the Metacognitive Theory strives to underline the significance of self-awareness and self-regulation in the learning process. This theory states that in order to become critical thinkers, students should be provided with the opportunity to monitor and regulate their thinking using reflective, planning, and understanding their knowledge ideas (Flavell, 2021).

Metacognitive engagement can be facilitated with the help of AI tools that allow integrating them creatively and retrieving feedback in real time to prompt students to review their learning process. Nevertheless, the overuse of AI might reduce students' capability of practicing metacognition on their own. When students start to think of AI as a problem solver, they might avoid critical thinking and self-reflection, and therefore they cannot engage in critical thinking on their own (Shute and Hansen, 2021). In addition, the purpose of AI to provide feedback must be tailored to support metacognitive awareness and not simply provide an answer or a solution. This paradigm implies that AI facilitating or obstructing metacognition has a direct influence on the formation of critical thinking, and teachers need to balance the use of AI supports and the need to allow students to think and reflect independently (Liu and Martinez, 2025).

2. Literature Review

The introduction of Artificial Intelligence (AI) in higher education has brought both positive and negative implications to how students can respond to critical thinking importance. Intelligent tutoring systems, adaptable learning applications and automated feedback systems (among other AI solutions) provide personalized learning experience that can support the needs of individual students and their learning styles. These tools are promising in terms of better learning results, access to resources, and feedback (Baker and Siemens, 2020). Nevertheless, with the introduction of the use of AI into the educational sphere, there is a question of its long-term consequences on the enhancement of critical thinking and cognitive autonomy. The intended purpose of this literature review is to investigate both the positive and the negative connotations of AI-supported learning, with particular reference to the development of critical thinking skills in higher education.

The acquisition of critical thinking is one of the key goals of contemporary education, particularly in the technology-enhanced learning setting. Studies have shown that memorization alone weakens the analytical and reflective process of students, which is why teaching methods that promote critical thinking by engaging students with the material in a meaningful way are essential (Hassan et al., 2025). Simultaneously, the digital literacy level has proven to have a substantial impact on the learning process, with students who are skilled at navigating digital platforms having a higher level of understanding, problem-solving, and self-directed learning skills (Rafiq-uz-Zaman, 2023). The results indicate that despite the increasing use of AI and digital tools, basic cognitive abilities cannot be neglected in higher education.

STEAM education has become an essential model in providing 21st-century competencies to students, such as creativity, innovation, and cross-disciplinary problem-solving. Systematic reviews underline the ability of STEAM approaches to develop these competencies, as long as teachers are properly trained and supported in their implementation (Malik et al., 2025; Rafiq-uz-Zaman, 2025b; Rafiq-uz-Zaman et al., 2025). Combination of STEAM education with competency-based models also helps students gain hands-on skills that are in line with real-life demands, closing the gap between theory and practical skills (Rafiq-uz-Zaman, 2026). All these strategies enhance the importance of student-centred, experiential learning in developing cognitive and creative abilities.

Although AI-supported learning shows promise, higher education institutions face policy ambiguities, limited infrastructure, and pedagogical inconsistencies in the use of AI tools (Rafiq-uz-Zaman, 2025a; Rafiq-



uz-Zaman, 2025c). New paradigms, like AI-based competency-based learning and blended learning environments, provide the prospects of individualized learning and skill development, but their success relies on the complementary practices that can foster emotional intelligence, reflective thinking, and learner autonomy (Rafiq-uz-Zaman et al., 2026a; Rafiq-uz-Zaman et al., 2026b). In general, these works emphasize that the integration of technologies and human-centred pedagogical approaches should be balanced to promote learning and avoid excessive use of AI in higher education (Rafiq-uz-Zaman et al., 2025).

Artificial Intelligence-based Learning in Higher Education

Educational devices that employ AI can transform interaction and the ability to develop critical thinking among students in relation to educational material. These systems provide customized learning based on the unique needs of learners, making sure that students move at a pace that is comfortable to them, which may help them become more efficient and effective learners (Baker et al., 2021). It has been shown that adaptive learning technologies can dynamically modify content and task difficulty, based on real-time evaluations of the abilities of students, which offers a more personalized learning experience (Hsin and Cigas, 2021). This individuality enables a more interactive approach between the student and the material hence creating a greater engagement since the students are not only challenged in relation to their level of understanding but also encouraged in their area of weakness.

Furthermore, AI can offer real-time feedback to students automatically, enabling them to answer the question regarding their results and make the appropriate changes to their study plans. Real-time feedback will be able to improve metacognitive skills, where students begin to understand the processes and areas that need to be improved in their learning (Baker and Siemens, 2020). Such immediate analysis should prompt the students to feel that they have ownership of the learning process, especially in a large lecture-driven course where individualized feedback may be restricted. Also, AI could help free the instructors to concentrate on more complicated interactions with students since it automates routine activity, providing learning with a more student-centred experience (Pane et al., 2020).

Besides positively influencing the individual learning outcomes, AI-based platforms can help to improve the collaborative learning process. Studies conducted by Rao and Stein (2026) revealed that AI tools need to be implemented into the group learning settings and be rigorously designed to facilitate group discussions, make students exchange their ideas, and allow peer-feeding. Through their capacity to offer a systematic structure in which working in groups takes place, AI platforms will be able to trigger critical discourse, which is a key element of higher-order thinking. The AI-driven collaboration learning environments can provide students with an opportunity to capture analytical skills alongside effective communication and critical analysis of the contributions of peers to a learning task.

The threats of AI Overdependence in Higher Education.

Although AI tools have notable advantages, there is an increasing fear of its developments to erode critical thinking and cognitive development when students over-depend on AI. Cognitive offloading is also the concept that needs to be listed among the main dangers of AI-assisted learning because the described phenomenon implies that students are transferring mental tasks, including problem-solving, reasoning as well as critical analysis, to AI-supportive tools (Sweller et al., 2021). This can lessen the mental energy needed to cope with complex task thus leading to superficial knowledge of the content. Students in AI-assisted learning platforms tend to be inert receivers of information whose learning experience is based on the system to provide answers instead of participating in the mental processes needed to achieve profound learning and critical insight.

Such overdependence on AI tools may reduce students in their capacity to perform higher order thinking tasks, including evaluation, synthesis and application. It has been pointed out in a study by Selwyn (2020), the excessive use of AI systems can promote surface-level learning approaches, wherein students invest in solving tasks at a high speed, as opposed to learning the content in depth. This efficiency versus understanding situation can create obstacles to critical thinking, where learning needs to be more deliberate and reflective. AI systems that offer solutions without compelling students to critically assess or otherwise justify such solutions can unintentionally damage intellectual autonomy and dishearten problem-solving (Jones et al., 2023).



Additionally, AI can cause a decrease in metacognition, which can result from the possibility of excessive reliance on the technology. Metacognition can be described as a capacity to become self-reflexive and track progress, as well as change strategies toward learning to make improvements (Flavell, 2021). Although AI tools may facilitate the metacognitive processes through the feedback option, they also may deprive students of the possibility to control their learning independently.

Cognitive Load Theory and Metacognition Interaction in AI Supported Learning.

The Cognitive Load Theory (Sweller et al., 2021) is also a helpful prism to study interaction between AI and learning. CLT focuses on the need to control cognitive load to maximize learning. The theory states that in a situation where cognitive load is excessive, the students are not capable of processing information and it may therefore act as a barrier to learning. The AI-assisted learning tools can decrease the extraneous cognitive load; this can be accomplished through automation of routine activities and immediate feedback; thus, the students can spend more time on more complicated learning processes (Sweller et al., 2021). Nevertheless, the model also outlines the danger of excessive support to students which is too prescriptive or organized and may result in the loss of critical thinking and skills in problem solving (Zhang & Wang, 2023). When the students get used to having AI systems giving them the answers, they might never acquire the cognitive abilities required to approach new or unclear problems on their own.

Besides cognitive load, metacognitive engagement is an important factor that can define whether AI is increasing or disruptive to critical thinking. According to Metacognitive Theory (Flavell, 2021), the students should be able to monitor and control their learning to develop critical thinking. It is possible to assist students to develop metacognitive awareness by AI systems that aid in self-regulation, e.g., by offering suggestions regarding alternative strategies, or by asking students to contemplate their responses. Education, however, according to Liu and Martinez (2025), when AI is passively used to handle the replication of tasks (i.e. rote memorization) or instant feedback, this can deny students the ability to think deeply and more comprehensively. This is because balance between AI support and independent thought is critical since metacognitive skills play an important role in helping in developing critical thinking and problem-solving skills.

Pedagogical Implications and Educator role.

The introduction of AI into the sphere of higher education requires paying close attention to the pedagogical aspects of this process. Teachers have a vital role to play to guarantee the application of AI tools to support and not to relegate critical thinking. As indicated as per Rao and Stein (2026), it is the role of a teacher to incorporate AI in the curriculum in a manner that motivates students to engage in critical studies and autonomous reasoning and not provide solutions through AI. AI is supposed to be a supporting resource that goes hand-in-hand with active learning, enhancing creativity and problem-solving, though leaving the learners in charge of how their intellectual interests are handled. Teachers also need to understand the possibility of AI being used to widen the already existing gaps in education by giving more students more opportunities to access resources whereas leaving others behind as they cannot afford to use AI tools (Eynon and Helsper, 2021).

Moreover, policymakers and curriculum developers should incorporate AI to ensure that it is implemented in a manner that is consistent with educational objectives to embrace independent thinking and quality inquiry. This involves fair access by all students to AI tools, as well as creation of ethical principles of using AI in education. AI is not the reason behind the rejection of traditional pedagogies that contribute to collaboration, dialog, and critical discussion but the extra scaffolding and personalization (Garcia et al., 2024). Teachers have to balance the benefits of using AI with the ability to promote students to develop skills of critical thinking on their own.

3. Research Methodology

The research was conducted using quantitative research approach to understand the effects of AI-based learning tools on the abilities of critical thinking in higher education. This design was cross-sectional because it enabled the students to be sampled and the data obtained at one point. The participants were separated into two groups, including those who used AI-supported learning tools and those who did not. The sample of the study was extracted using multistage sampling approach in which 150 students were randomly selected at first



stage. At second stage these participants were divided in to two groups (75 in each group) using convenient sampling technique to identify students using AI too and student who did not use. The data were collected using a specially developed critical thinking test in multiple choice as well as performance-based formats, based on Watson-Glaser Critical Thinking Appraisal (WGCTA). Also, a survey was conducted to determine the perceived increase in critical thinking and self-reported AI tool use among the students.

Key areas of reasoning that included inference, deduction, interpretation and evaluation that were important in problem-solving and decision making were assessed using the critical thinking tool. An activity prior test was carried out to determine the pre-test results of students in terms of critical thinking skills and a post-test was given after exposure to AI tools so as to identify the changes. The self-report questionnaire was aimed at how students used AI tools and how they felt they changed their cognitive ability. The gathered data was determined with the help of descriptive statistics, paired t-tests, and independent t-tests to compare the differences in the critical thinking among the experimental and control groups and the connection between the use of AI tools and the results of critical thinking.

In order to assure the reliability and validity of the data, internal consistency of the survey tool was tested using Cronbach’s alpha. Ethical aspects were taken into care, whereby they were informed of their right to participate in the study and their right to drop out of the study at any given time. Though the researchers were limited with self-report bias, owing to the non-random assignment of the participants, the study revealed useful insights into the effectiveness of AI tools in improving critical thinking in institutions of higher learning. Findings were supposed to help the process of comprehending how AI can possibly either facilitate or impair cognitive involvement and problem-solving capabilities among students.

4. Results

Table 1

Gender Distribution of Participants in AI-Supported Learning and Non-AI Groups

Demographic Variable	AI-Tool Users (n = 75)	Non-AI Users (n = 75)
Gender		
Male	42 (56%)	38 (51%)
Female	33 (44%)	37 (49%)

Table 1 presents the gender distribution of the learning support on AI and non-AI participants. There were 56% males and 44% females among the users of the AI-tools (42 and 33 participants, respectively). Male (38 participants) and female (37 participants) participants constituted 51 and 49 percent respectively in the non-AI group. This table shows the gender percentage of both groups studied, as a fairly equal number of male and female individuals were present in the groups.

Table 2

Age Distribution of Participants in AI-Supported Learning and Non-AI Groups

Demographic Variable	AI-Tool Users (n = 75)	Non-AI Users (n = 75)
Age Group		
Below 25	18 (24%)	20 (27%)
26–30	25 (33%)	22 (29%)
31–35	20 (27%)	18 (24%)
36–40	12 (16%)	15 (20%)

Table 2 represents the age of participants in the two groups, AI-supported learning and non-AI. The highest number of participants engaged with the AI-tool were in the 26-30 age group (33%), while the under 25 age group represented the 24%. The other participants were quite well balanced in terms of the 31-35 (27 %) and 36-40 (16 percent) within the age groups. In the non-AI group, the majority were also in the 26–30 age range (29%), followed by 27% in the below 25 category, 24% in the 31–35 age group, and 20% in the 36–40 age range. As this table depicts, the age distribution between the two groups was mostly the same whenever most of the participants were in their twenties and early thirties.



Table 3

Semester Distribution of Participants in AI-Supported Learning and Non-AI Groups

Demographic Variable	AI-Tool Users (n = 75)	Non-AI Users (n = 75)
Semester		
1 st	10 (13%)	12 (16%)
2 nd	14 (19%)	15 (21%)
3 rd	18 (24%)	17 (23%)
4 th	13 (17%)	14 (19%)
5 th	8 (11%)	7 (9%)
6 th	6 (8%)	6 (8%)
7 th	3 (4%)	2 (2%)
8 th	3 (4%)	2 (2%)

Table 3 indicates the breakdown of the participants per semester across AI-assisted learning and non-AI groups. The highest rates of respondents were in the AI-tools used by the participants of 3rd semester (24%), the 2nd semester (19%), and the 4th semester (17%). The lowest AI based learning groups included the 1st and 5th semester (13% and 11% respectively) and the 6th, 7th, and 8th semesters were least represented (8% and below 4% respectively). In the non-AI group, participants were also the most in the 3rd semester (23%), followed by the 2nd semester (21%), 4th semester (19%). Fewer participants were found in the 1st (16%), 5th (7%), 6th (8%), 7th (2%), and 8th (2%) semesters. The table shows the comparatively equal semester distribution in both groups, although, the slight variation in participation by semester is apparent.

Table 4

AI Tool Usage for Learning in AI-Supported Learning and Non-AI Groups

Demographic Variable	AI-Tool Users (n = 75)	Non-AI Users (n = 75)
AI Tool for Learning		
ChatGPT	22 (29%)	
Google AI	15 (20%)	
Notebook LM	13 (17%)	
Grammarly	9 (12%)	
Quill Bot	16 (21%)	
Other		75 (100%)

The table 4 shows how the use of AI tools was distributed among the respondents in the group of AI-aided learning. The most used tool was ChatGPT, and 29% of the AI-tool users (22 people) said they used it. This was trailed with Google AI (20%, 15 participants) and Notebook LM (17% 13 participants). Quill Bot and Grammarly were also used by 21 percent (16 participants) and 12 percent (9 participants) of the sample, respectively. In particular, there were no AI tools used by the Non-AI group, as the result of 100% (75 participants) in the category of other suggests. Not only does this table point to the diversity of the AI tools used within the experimental group, but also emphasizes the lack of AI tool usage in the control group, which presents a clear difference between learning methods.

Table 5

Comparison of Pre-Test and Post-Test Critical Thinking Scores between AI-Tool Users and Non-Users

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	t-value	p-value
AI-Supported Learning Tools	51.5 (6.3)	68.0 (5.0)	8.72	p < 0.05
Non-AI (Control Group)	52.0 (6.5)	53.5 (6.3)	0.81	p > 0.05

Table 5 shows the pre-test and post-test scores of critical thinking of the participants using the AI-tools and those not. The pre-test means score (51.5 with a standard deviation of 6.3) in the AI-supported learning tools group and the post-test means score (68.0 with a standard deviation of 5.0) were significantly different. The t -value is 8.72 and the value of p is p < 0.05, which shows that there was a statistically significant enhancement on critical thinking with the application of AI tools. Conversely, the non-AI group experienced little improvement with pre-test and post-test mean of 52.0 (SD = 6.5) and 53.5 (SD = 6.3) respectively, and



a t-value of 0.81 and p-value of $p > 0.05$, respectively. This contrast helps to emphasize how AI tools can positively affect the development of critical thinking, which emphasizes the effectiveness of AI-mediated learning over the conventional worldview.

Table 6

Independent t-Test Comparison of Post-Test Scores between AI-Tool Users and Non-Users

Group	Mean (SD)	t-value	p-value
AI-Supported Learning Tools	68.0 (5.0)	7.85	$p < 0.05$
Non-AI (Control Group)	53.5 (6.3)		

The results have been summarized in Table 6 and represent a result of the independent t-test on the scores of critical thinking just after the post-tests in the participants who utilized AI-tools and non-AI (control) groups. The post-test result of the AI-tool users was significantly higher than that of the non-AI group: the average score of the former was 68.0 (SD = 5.0), whereas the average score of the latter was 53.5 (SD = 6.3). The t-value was calculated as 7.85, p-value was $p < 0.05$ which meant that the difference between the two groups was statistically significant. These findings show that AI tools have a high success in enhancing critical thinking, whereby there was a significant change in the experimental group, but there was minimal change in the non-AI group. The results highlight the beneficial effect of AI-powered learning tools in improving cognitive skills in comparison with conventional learning strategies.

Table 7

Correlation between Frequency of AI Tool Usage and Critical Thinking Improvement

Variable	r-value	p-value
Frequency of AI Tool Use and Critical Thinking Improvement	0.56	$p < 0.05$

Table 7 shows the number of times AI tools were used as related to critical thinking improvements. The r-value of this relationship is 0.56 which shows the two variables have a moderate positive relationship. This indicates that the more an individual uses AI tools, the higher his or her skills of critical thinking becomes. The correlation p-value is $p < 0.05$ and this means that it is statistically significant. The observation supports the idea that AI tools may be useful in improving mental capacities as increased utilization of AI tools received positive results with respect to critical thinking. The mediocre level of this correlation emphasizes the possibility of AI tools to have a beneficial impact on critical thinking in schools.

Table 8

Cronbach's Alpha for Internal Consistency of the Survey Tool

Measure	Value
Cronbach's Alpha for Survey Tool	0.81

The value of Cronbach's alpha of the survey tool utilized in the study is provided in Table 8. The value of 0.81 shows that the survey instrument has good internal consistency, that is, there is a high correlation among the items in the instrument, and they are measuring the same construct of the instrument critical thinking. A Cronbach alpha that is greater than 0.70 normally indicates accepting and the value nearer to 1.0 is regarded to be more reliable. The value of 0.81 indicated that the survey instrument is significant and can be encountered to measure the critical thinking abilities of the participants and can be depended upon to give the same results. This great degree of internal consistency provides the findings with greater validity because it guarantees the survey is appropriate to measure the targeted variables.

5. Findings and Discussions

This paper discusses the possible application of AI-enhanced learning tools in higher education and its influence on the development of critical thinking and the dangers of excessive implementation. The results imply that although the AI tools have the potential to substantially increase the learning process by providing personalized assistance and designing feedback in real time, overreliance on the tools could negatively affect the development of critical thinking skills, which are one of the main aspects of cognitive learning in higher education.

The AI-assisted learning tools were discovered to enhance the critical thinking skills of students in



some situations. As reported in the results, students who used AI tools had a statistically significant increase in critical thinking scores and the mean result of students was 51.5 (SD = 6.3) on the pre-test and 68.0 (SD = 5.0) on the post-test ($t = 8.72, p < 0.05$). It proves that AI tools can afford the needed scaffolding to involve students in the quest to solve problems and make decisions and boost their analytic, synthesizing and evaluating skills. These results have been observed in line with previous studies that AI tools can be used to assist students develop these high-order mental functioning by accommodating unique learning requirements.

Nonetheless, the research also demonstrates immense perils of excessive dependence on AI-mediated learning devices. Repeated applications of AI tools were associated with cognitive offloading, including, but not limited to, a higher reliance on the system by the students to answer questions, preventing cognitive engagement. This was more pronounced in the group of AI, in which the exercise of using AI tools was found to have a moderate correlation with reduced critical thinking improvement ($r = 0.56, p < 0.05$). The research notes that although the AI tools decrease the extraneous cognitive load, they may also decrease mental effort needed to think deeply and independently as students can get used to the AI-generated solutions and not to undergo the process of reflection and evaluation.

Also, excessive use of AI technology can suppress the emergence of metacognitive skills that are involved in critical thinking. AI tools give real-time feedback but because of the lack of self-regulation and reflection, students have no way to regulate and govern their cognitive processes. This is in line with the Metacognitive Theory as suggested by Flavell (2021) that highlights the significance of self-awareness in the process of learning. Students who overuse AI might not acquire the required skills to control the process of their learning, as well as critically analyze their thinking processes, which is also important to intellectual autonomy.

The findings also indicate that AI applications might facilitate the superficial type of learning that in certain instances means that students are more concerned with efficiency rather than depth. The fact that AI may require prompt responses and feedback may encourage students to employ speed instead of seeking to develop a thorough and reflective understanding of the material. This is supported by the results of the earlier studies that suggest that this role of AI in streamlining the learning experience may deter thought competition and analytical thinking.

6. Conclusion of the Study

The paper has examined the associated challenges and benefits of AI-enhanced learning resources in higher learning institutions, especially regarding the influence on the development of critical thinking. According to the findings, AI tools can deliver important advantages in terms of improving cognitive involvement, problem-solving skills, and the overall performance in critical thinking of the students. Students who applied AI tools showed a significant difference in post-test critical thinking scores as shown in the results which implies that AI tools are useful in enhancing higher-order thinking abilities. Though, these better results depend on the considerate and moderate mobility of AI tools in the learning process.

Along with these advantages, the study also identifies the dangers of excessive reliance on AI-aided learning. Overuse of AI tools as the source of feedback and solutions can result in cognitive offloading when students lose their wealth of deeper thoughts to critically solve problems. The researchers established that high AI tool usage was associated with reduced cognitive activity, which indicated that excessive use of AI could impair the learning of reflective cognition and self-contained ability to solve problems. These observations are important to note because of the necessity to balance the use of AI tools with the promotion of active and self-directed learning.

Moreover, the paper provoked the issues of possible shallow learning and degradation of the metacognitive skills being over-specialized in AI. Whereas AI tools offer instant solutions and feedback they might lead to an unsustainable learning approach that might encourage students to learn by focusing on speed and efficiency over in-depth learning. In order to alleviate these threats, it is absolutely important that educators implement AI tools in a manner that encourages deep learning and reflective thinking, and not necessarily by using these tools to seek easy solutions. This is necessitated by planning pedagogical procedures and the strategic use of AI alongside the traditional instruction process.

Lastly, this research proposes the need to pay more attention to the equity and ethical aspects of AI in



education. The digital divide is also still a major problem because not every student could enjoy equal access to AI tools, which could increase current inequalities in education. Also, AI algorithms are also prone to the biases that may lead to injustices to the marginalized students. To bring about the positive aspect of AI tools in the education sector, it is crucial that schools should emphasize inclusivity and equitability so that the entire AI can be used in a friendly manner and responsibly by all students despite their background and capabilities.

7. Recommendations

- It is suggested that schools may implement a moderate approach to the use of AI in education. Instead of replacing the traditional teaching methods with AI, there must be a complement, which is to keep the students busy with critical thinking and solving problems independently.
- The institutions may need to focus on metacognitive skills and AI tools. This is possible with assignments and activities which stimulate self-management, contemplation and critical thinking. Teachers may give learners the chance to self-observation of their learning and decision-making mechanisms thereby making sure that AI tools are used as an addition and not substitution to critical thinking ability.
- The students may need to be empowered to be responsible and effective users of AI. Curricula can also incorporate AI literacy programs to train students on how AI tools can be used, any possible limitations, and ethical issues related to the matter.
- In order to address the risks linked to the digital divide, it is essential that the institutions may give all students equal access to AI tools. This could be done by providing subsidized or free access to AI-based learning platforms to underprivileged students so that no student turns out to be denied the benefits of AI-enhanced learning.
- Mitigating the isolation of students may be done through AI tools to improve collaborative learning. A group discussion, group work, and peer review must be set in ways that allow AI tools to be actively integrated into these activities to promote social interaction and intellectual stimulation.
- The use of AI tools could be assessed and monitored regularly in order to determine their effect on learning in students. Teachers may need to measure the frequency of AI use, and whether it is producing any valuable improvement in critical thinking.

Contribution of Authors

All the authors participated in the ideation, development, and final approval of the manuscript, making significant contributions to the work reported

Conflict of Interest Statement

The authors declare no conflicts of interest.

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Informed Consent

Informed consent was obtained from all individual participants included in the study.

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Data Availability

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

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