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The Impact of AI on Critical Thinking and Problem-Solving on Student Skills in Higher Education: An Empirical Study

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Abstract

This study examines how students are able to think critically and solve problems when Artificial Intelligence (AI) tools are used in higher education. Using a kind of experimental research design, data were collected from sixteen undergraduate students with one group using AI-assisted learning and the other using traditional learning methods. In order to evaluate the improvements in cognitive performances with pre-test and post-test assessments, semi-structured interviews were conducted. The results indicated that the group using AI tools showed better improvement compared to the group that did not use an AI tool. For critical thinking, they had a delta of 1.41 meaning they did better at that score than the non-AI. The t-test score for the team was 4.12 and p-value < .01. Likewise, the delta for problem solving was 2.73, t-test=5.02 showing a p-value<.001. The estimated effect sizes suggest the effects of AI on higher-order cognition using all data were medium to large, d = 0.65−0.81. The qualitative information from the findings supported this. The AI technologies promoted engagement, student autonomy and strategic reasoning among students using it. AI-enhanced instruction, as per the analysis, can help learners develop critical reflections in addition to adapting learning and essential skills.

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Recommendations stress the importance of incorporating AI literacy and ethics in curricula to maximize rewards and reduce cognitive dependency.

Keywords: Artificial Intelligence, Critical Thinking, Problem-Solving, Higher Education, Cognitive Skills.

أثر الذكاء الاصطناعي على التفكير النقدي وحل المشكلات ومهارات الطلاب في التعليم العالي: دراسة تجريبية

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الملخص

تتناول هذه الدراسة قدرة الطلاب على التفكير النقدي وحل المشكلات عند استخدام أدوات الذكاء الاصطناعي في التعليم العالي .وباستخدام تصميم بحث تجريبي، جمعت البيانات من ستة عشر طالبا جامعيا، حيث قسموا إلى مجموعتين: الأولى استخدمت التعلم المدعوم بالذكاء الاصطناعي، والثانية استخدمت أساليب التعلم التقليدية .ولتقييم التحسن في الأداء المعرفي من خلال اختبارات قبلية وبعدية، أُجريت مقابلات شبه منظمة .أشارت النتائج إلى أن المجموعة التي استخدمت أدوات الذكاء الاصطناعي حققت تحسنا ملحوظا مقارنة بالمجموعة الأخرى. ففي التفكير النقدي، بلغ الفرق 1.41، أي أنهم تفوقوا على المجموعة الأخرى في هذا الجانب .وكانت نتيجة اختبار t للمجموعة 4.12، وقيمة p أقل من 0.01 .وبالمثل، بلغ الفرق في حل المشكلات 2.73، ونتيجة اختبار t تساوي 5.02،

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وقيمة p أقل من 0.001 .وتشير أحجام التأثير المقدرة إلى أن تأثير الذكاء الاصطناعي على القدرات المعرفية العليا، باستخدام جميع البيانات، كان متوسطا إلى كبير، حيث d = 0.65–0.81. أكدت المعلومات النوعية المستقاة من نتائج هذا الاستبيان والتي عززت تقنيات الذكاء الاصطناعي التفاعل والاستقلالية لدى الطلاب، مما عزز التفكير الاستراتيجي لديهم .ووفقا للتحليل، يمكن للتعليم المعزز بالذكاء الاصطناعي أن يساعد المتعلمين على تطوير مهارات التفكير النقدي، بالإضافة إلى تكييف أساليب التعلم واكتساب المهارات الأساسية. وتؤكد التوصيات على أهمية دمج الوعي بأخلاقيات الذكاء الاصطناعي في المناهج الدراسية لتحقيق أقصى استفادة وتقليل الاعتماد على المعرفة النظرية.

الكلمات المفتاحية: الذكاء الاصطناعي، التفكير النقدي، حل المشكلات، التعليم العالي، المهارات المعرفية.

1. Introduction

Data representation and manually finding patterns in data using human expertise are being rapidly replaced by artificial intelligence (AI). This transformation represents one of the most significant shifts in modern society (Chen et al., 2023). Automated pattern detection and the ability of new machine learning algorithms to independently develop optimized solutions for specific analytical tasks have revolutionized how knowledge is generated and applied. This automation benefits both educators and researchers by improving efficiency and simultaneously increasing opportunities to deal with learning and cognitive processes more in-depth. Janiesch et al., 2021). In today's higher education sector, AI is one of the most important technologies for both students and teachers. AI can support students' learning processes, and enable instructors to design instruction in a more effective way.

As schools and colleges adopt AI based tools, one avenue of research receiving increasing attention is the study of how these tools affect essential cognitive skills such as analysis and problem-solving abilities. The ability to think critically and reason effectively are skills that students require to thrive academically and develop skills necessary for life-long learning.

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This study looks at AI-assisted instruction affects students' critical thinking and problem-solving ability in higher education. Researchers are comparing students who learned via AI tools with those who learned through traditional methods. This will help in empirically analyzing if tools significantly contribute to enhanced higher-order cognitive development.

2. Literature Review

The capacity to think critically and deal with different life problems is a lifelong learning process by higher education, especially by technology. When students improve their cognitive skills, they begin thinking about and evaluating this knowledge. In addition, they will also develop modified strategies for tackling new issues. Previous research showed that more cognitive efforts must be accompanied by more capability as otherwise, it leads to frustration and disengagement (Elbyaly & Elfeky, 2023). It is expected of higher education institutions to foster critical thinking that enables sound reasoning, decision-making, and reflective judgment. Nadeak and Naibaho (2020) have stated that critical thinkers are aware of their actions and are able to use knowledge flexibly across situations. But there is limited understanding of how transfer of these skills happens in a digital or artificial intelligence enhanced learning environment (Al-Adwan et al., 2022; Hsieh & Huang, 2020).

2.1 The Importance of Critical Thinking in Higher Education

The term critical thinking is interpreted to refer to one's capacity to analyze, evaluate, and interpret information as well as to reach rational and reasonable conclusions. According to Paul and Elder (2006), it is a disciplined process used to develop certain intellectual traits essential for reasoning and problem solving. Tang, et al. (2020) noted that curiosity, skepticism, and reflective judgment must be fostered to cultivate critical thinking. This skill is not just about analyzing data but is a type of motivation or disposition to challenge assumptions and work through complex questions (Monteiro et al., 2020). By allowing students to carry out independent investigation and evidence-based reasoning, these skills are crucial in higher education. These skills will not just help in academic success, but further employability (Fuchs, 2023).

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2.2 Problem-solving Skills Involved Success of Students

Solving problems is somewhat similar to critical thinking. It, however, focuses on the ability to identify, produce, and evaluate solutions. The demand for "problem-solving ability" has increased over the years in the changing job landscape (Szabo et al., 2020; Güleç, 2020). Today's students who think critically and solve problems collaboratively are more adaptable and innovative. Studies show effective problem solving depends on knowledge, reasoning ability, and regulation of reasoning (Alam & Mohanty, 2023). Thus, improving problem solving skills in higher education can enhance students' cognitive flexibility and professional readiness.

2.3 Impact of AI on Education

AI helps to personalize instructional plans and enhance effectiveness in learning. AI technology can mimic particular aspects of human reasoning for optimizing adaptive feedback, automating assessments and personalizing learning. Studies have shown that AI enhances high-order thinking through the automation of routine tasks permitting learners to engage in complex reasoning especially creativity (Ahmad et al., 2020). AI can also boost and enhance teacher productivity through the automation of routine tasks as well as streamlining decision-making. But it can lead to cognitive downsizing and passive learning when systems are relied on to replace human judgment, rather than complement it (Huang & Rust, 2021). For equal integration, one must adapt and balance the AI-powered tracking about personalization with pedagogical development, so that students do not lose energy capacity for pursuit and critical reflection (Angwaomaodoko, 2023). When used properly, AI can humanize learning, enhance inclusion and ensure understanding through interaction and real-time responses.

3. Methodology

3.1 Research Design

This study employed a case study–based quasi-experimental research design to investigate how AI-aided instruction influences students' critical thinking and problem-solving skills in higher education. The design was selected because it allows for an in-depth examination of a contemporary educational phenomenon within its

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real-world context (Yin, 2014). The approach combined quantitative and qualitative methods to enhance validity through triangulation. The researchers created an experimental group, given AI-aided instruction, and a control group, exposed to traditional teaching. Both groups did pre-test and post-test to see improvement in their critical thinking and problem-solving skill. Further, semi-structured interviews helped researchers learn how students feel about AI-learning.

3.2 Data Collection

Online surveys and structured assessments were used to collect primary data. The survey instrument to measure cognitive skill development was subjected to expert review for content accuracy and reliability. Participants responded to the study instruments through surveys hosted on SurveyMonkey. The researchers selected sixteen undergraduate students to participate in the study through purposeful sampling. This idea was to provide that the respondents possess certain features essential for the study. Students should get enroll in higher education and learn about AI usage in studies. The selected sample was small but the produced report meaningfully explored the students' experiences and cognitive outcomes. Ethical protocols were observed throughout the study. Consent was obtained from all participants and they were assured of their voluntary participation and of confidentiality.

3.3 Sample Selection

The research included participants from both public and private universities to enhance representativeness. Students from engineering and management disciplines were prioritized, given the higher prevalence of AI use in these fields. Random sampling within these disciplines ensured that each student had an equal opportunity for selection, while proportional allocation-maintained balance between institutions and cognitive levels. The students were divided based on their academic status. The ones that fell under the top 50% were selected as high-cognitive whereas the other ones from the lower 50% were selected as low-cognitive based on cumulative GPA. Being stratified like this allowed for comparisons at different levels of ability on the cognitive test. Data collection was conducted over a six-month period and included interviews with faculty to

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identify the AI tools most frequently integrated into instruction. These interviews supplemented quantitative results by contextualizing how AI was used to support students' learning processes.

4. Results and Findings

Researchers investigated AI-facilitated lessons and the effect on students' critical thinking and problem-solving skills in higher education. Data from pre and post-tests were analyzed for both experimental (AI-aided) and control (traditional) groups with qualitative insights from semi-structured interviews.

4.1 AI Impact on Critical Thinking Skills

The students in the AI-aided group improved their critical thinking more than the control group. Table 1 shows the mean scores of both the groups before and after instruction.

Table 1. Pre- and Post-Test Mean Scores for Critical Thinking

Group	Pre-Test Mean	Post-Test Mean	Difference
Experimental (AI-aided)	**35.16**	**36.57**	**+1.41**
Control (Traditional)	**34.94**	**35.78**	**+0.84**

As shown in Figure 1, both groups improved, but the experimental group's mean gain ($\Delta = 1.41$) was noticeably higher.

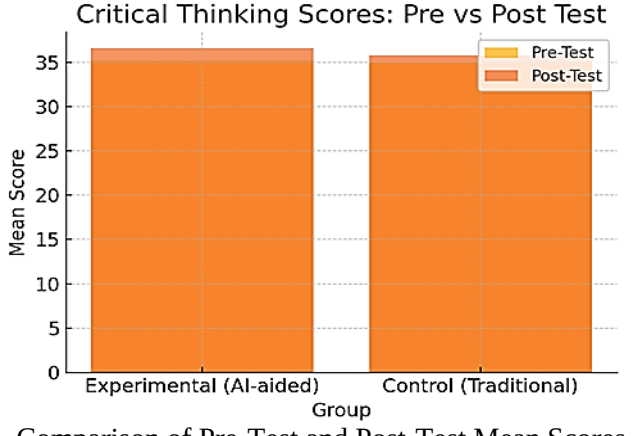

Figure 1. Comparison of Pre-Test and Post-Test Mean Scores for Critical Thinking.

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An analysis of covariance (ANCOVA) was conducted to control for pre-test effects. The post-test mean score of the AI-aided group was significantly higher than the non-AI aided group, $F(1,30) = 5.76$, $p < .05$ confirming that AI instruction program enhances critical thinking ability (Mdiff = 0.91). A paired-sample t-test was performed to validate these results (Table 2).

Table 2. Paired Sample T-Test Results for Critical Thinking

Group	Mean Difference	SD	t-value	Df	p-value	Significance
Experimental (AI-aided)	1.41	0.82	4.12	15	0.001	Significant
Control (Traditional)	0.84	0.79	2.15	15	0.045	Significant

Both group members showed significant improvement, although, AI-aided expression members made greater improvement. The results offered strong support for the hypothesis that use of AI tools facilitates reflection and critical analysis with feedback which is personalized and cognitive scaffolding. Qualitative interviews supported the quantitative data. Students said using AI tools allowed them to “see things from different angles” and “develop strategies for reasoning”. By contrast, students in the control groups faced more difficulties transferring their critical thinking without AI assistance.

4.2 Impact of AI on Problem-Solving Skills

AI-aided instruction also improved students’ problem-solving abilities. The experimental group displayed a larger gain in mean scores compared to the control group (Table 3).

Table 3. Pre- and Post-Test Mean Scores for Problem-Solving

Group	Pre-Test Mean	Post-Test Mean	Difference
Experimental (AI-aided)	30.12	32.85	+2.73
Control (Traditional)	29.97	31.24	+1.27

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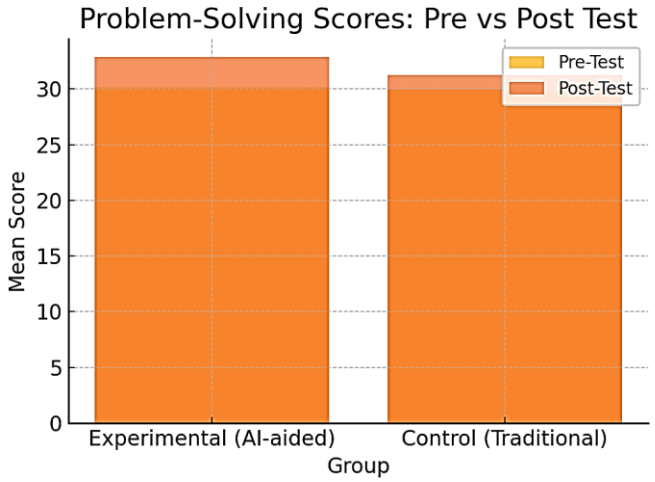

Figure 2. Comparison of Pre-Test and Post-Test Mean Scores for Problem-Solving Skills.

The AI-aided group's improvement ($\Delta = 2.73$) was more than double that of the control group ($\Delta = 1.27$), and the difference was statistically significant, $t(15) = 5.02$, $p < .001$, indicating a large effect ($d = 0.81$). Students in the experimental group reported that AI tools enabled real-time feedback and adaptive problem sequencing. One participant stated, "The AI system gave hints when I was stuck and helped me break problems into smaller steps." In contrast, control group students reported feeling "less confident tackling complex problems alone."

4.3 Insights into the Results

Overall, the findings show that the AI-based learning can enhance the skills. The result of effect size showed that the use of Edu-Quest assessment software had a medium effect on critical thinking ($d = 0.65$) and a large effect on problem-solving ($d=0.81$).

Table 4. Effect Size (Cohen's d) for Critical Thinking and Problem-Solving

Measure	Cohen's d	Interpretation
Critical Thinking	0.65	Medium Effect
Problem-Solving	0.81	Large Effect

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The data suggest that AI fosters adaptive learning environments by providing immediate feedback and tailored challenges that match students' cognitive levels. The benefits of these more personalized experiences probably help the experimental group perform better. Overall, the results seem to support that AI-supported teaching promotes critical reflection, strategic reasoning, and cognitive flexibility in higher education.

5. Discussion

This paper aims to find out how critical thinking and problem-solving skills of the university students impacted by AI. The findings show that AI-aided instruction contributes to cognitive domains with previous research confirming AI's pedagogical potential (Elbyaly & Elfeky, 2023; Tang et al., 2020**).** The outcomes of the quantitative investigation demonstrated that the group using AI made significantly greater gains in critical thinking ($\Delta = 1.41$, $p < .01$) and problem-solving ($\Delta = 2.73$, $p < .001$). According to qualitative findings, learners with AI support display enhanced confidence, flexibility, and engagement skills.

5.1 Interpretation of Findings

The fact that critical thinking improved suggests that the use of AI tools provided effective scaffolding for analytic thinking and metacognitive awareness. Students who utilized AI received feedback that adjusted to their needs and interactive prompts that encouraged deeper exploration and reflection. The study suggests that AI can foster higher-order thinking by creating individualized pathways for learners, allowing them to trial multiple strategies, according to Yang et al. (2021). AI's ability to break down tasks into smaller chunks and give users instant feedback on their progress could help people become better problem solvers. The actively learning through the dynamic feedback loops provide a range of opportunities and help the students regulate themselves which are two vital elements for the establishment of generalizable problem-solving skills (Szabo et al., 2020; Güleç, 2020). These results collectively confirm that by adopting AI's personalized and iterative learning environment, the teaching-learning experience can be improved. This can provide cognitive autonomy along with adequate scaffolding. Nonetheless, teachers should design AI

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integration properly to prevent passive learning behaviors or becoming too reliant on machines.

5.2 Implications for Higher Education

The findings have important implications for teaching in higher education. According to Southworth et al. (2023) and Ahmad et al. (2020), applying AI can help teachers concentrate more on teaching and less on admin work. More importantly, the AI development helps in creating critical thinking, creativity, easy thinking, and another ability of the 21st Century. By incorporating AI tools into the learning environment, teachers may differentiate their instruction. For example, AI based systems will detect skill gaps, adjust task difficulty and recommend resources. It allows the student to make meaningful decisions and fosters intrinsic motivation. According to Park and Kwon (2024), AI is essential for sustaining lifelong learning for anyone one chooses. Institutions must use AI transparently with privacy and non-discrimination to data. Dependence on algorithms produces irrationality in human beings. AI in education should lead to enhancing human thought and no causing a replacement of the human.

5.3Challenges and Opportunities

Some students might stop thinking if they depend on auto correct, etc. which means nothing to them, as per Huang and Rust, the AI forces organizations to make tasks simple, which in turn slows down the cognitive effort over a period of time. Teachers should therefore use AI as a thinking partner that triggers curiosity, discussion, and dispute, not as an answer engine. According to Seo et al. (2021), one positive aspect of AI is that it promotes diversity due to its adaptability to diverse learning styles along with rapid feedback in real time. Simulating the complex real-world scenarios, simulation capability enables the students to apply the theoretical knowledge they have acquired in the practical field. AI's adaptable analytics can offer support for formative assessment that can help teachers adapt better by identifying learning patterns. Teachers and students are empowered in their ability to construct learning outcomes that reinforce critical and creative thinking through an ongoing cycle of feedback and iteration.

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6. Conclusion

According to the above-developed theory on students' thinking and intelligence degradation occurring because of modern AI, finding results to support the theory would not be that difficult in today's education sector. Should the theory be true, it is an alarming state for the future generations' workforce productivity quality. The most productive set of students are those pursuing higher education in university and it is at this level they are being trained for a profession and pouring the foundation to using their intelligence and thinking capabilities in their related fields of work. These are the types of workers that AI is trying to develop technology for and should modern AI be hindering these students' capabilities, it would be a cause for AI industries to take note and carefully plan out the implementation of their technologies. The research on the impact of AI on critical thinking and problem-solving skills may serve as an indicator to the future generations' workforce productivity quality and should the results be the same as the theory, they may warrant support to redevelop AI to cater for intelligence-based development. In today's modern era of education, it is clear that the influence of AI and its related modern technologies have begun to take root. As can be seen in the higher education sector, technology has already started its steady dominance with the implementation of digital databases, online submission of assignments, virtual classrooms, email correspondence between students and lecturers, and also the recently popular online lectures that enable access to the students for viewing the lectures anytime and anywhere. The previous qualitative exploration generates strong insight that AI has already started to influence and change the higher education sector. As an evident tool of AI, technology has brought on many different modes of learning and interacting between students and lecturers. What would interest the AI field and related industries is whether these kinds of technology-driven changes are good enough or whether the embracement of AI implementation towards the intelligence of a higher education student would be more beneficial. AI industries would be looking at the cause and effect relationship of implementing modern AI to intelligence levels to better prepare a future generation workforce for acceptance of AI and its related technologies.

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7. Recommendations

To properly include AI in a higher education setting, this needs to include certain measures, while also ensuring the critical thinking and problem-solving abilities are augmented. One aspect is integrating AI into the curriculum. AI application is necessary for design of a course in college and universities to personalize learning and engaged cognition and avoid treating AI as a tutor. Instead, redesign the learning architecture for AI such that it will provide personalized lessons, instant feedback, and analytical or critical thinking. Through AI-based platforms, learning gaps can be identified for each individual student and the content's difficulty level will be adjusted accordingly, allowing students to learn at just the right level. Integrating of technology encourages student autonomy in learning and enhances students' motivation in study. It is also in line with the 21st century educational competency framework.

7.1 Faculty Training and Pedagogical Readiness

To make AI work in education, teachers have to commit to designing and implementing AI-infused learning experiences. It is recommended that faculty members receive continuous professional development on their AI literacy, including algorithmic bias, ethics, and design. Teachers shouldn't just be trained to use AI systems but also to decipher what AI tells them in relation to their students. Educational institutions must prepare training modules agreeing to more pedagogical and less technical use of AI so that innovation must remain in balance with human activities.

7.2 Improving how we teach critical thinking and problem solving

We should use AI to augment human intelligence, not replace it. Teachers can offer an open-ended question using AI and a real-world context to trigger a dialogue and or reflection. For example, adaptive AI tutors can offer counterarguments, allowing students to assess various viewpoints and enhance their reasoning. When we apply AI like this it supports guided discovery learning, along with metacognition and critical inquiry too. Using AI will uphold the intellectual demand for cognitive growth and offer useful feedback through adaptive learning.

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7.3 Policy and Ethical Considerations

Universities as well as policymakers have to create a framework to ensure transparency, data privacy, and fairness in the use of AI. AI assessments and feedback should be managed by the ethical policies defining the limits to automation. Institutions must also encourage the practice of AI literacy amongst students so that they understand how algorithms function and how to judge the outputs. When you are careful, that is, don't misuse things, we can use it.

8. Future Research Directions

Future studies should broaden their scope to include cross-disciplinary investigations and longitudinal studies of AI's effects on thinking processes. Research across different institutions could identify what demographic and cultural factors make a difference as well as differences in technologies. This research would help educators better understand how AI can be used for teaching, as well as limitations.

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