

AI Adoption Among Gen Z Learners: A Critical Examination of Cognitive Engagement and Critical Thinking

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Abstract- The swift adoption of artificial intelligence (AI) tools in higher education has greatly impacted the academic activities and study approaches of a large number of students, as well as their thinking styles. This research is concerned with the investigation of the parties' AI employment extent in multiple academic work, as well as exploring how patterns of AI use relate to level of critical thinking. Based on primary data, the study makes use of a structured questionnaire to assess the frequency and purpose of AI-aided learning, as well as self-reported measures of critical thinking, among undergraduate and graduate students. This descriptive–correlational study can reveal patterns of use and it can explore potential relationships. Descriptive statistics, reliability tests as well as correlation analyses will be used to analyse the data to investigate the relationship between the degree of AI implementation in academic work and students' cognitive engagement. The results will likely add substance to continuing conversations surrounding the potential educational fallout from AI and also offer actionable recommendations for educators attempting to right the scale between tech adoption and essential skills development.

Keywords- AI-assisted learning, Higher Education, Critical Thinking, artificial intelligence, cognitive engagement.

I. INTRODUCTION

The speed with which artificial intelligence (AI) has been woven into higher education has changed the ways in which students find information, work with learning materials, and acquire fundamental academic skills. Over the past ten years, AI tools—such as adaptive learning systems, intelligent tutoring systems, and generative AI assistants—have been integrated into routine academic work. These technologies offer enhanced efficiency, tailored instruction, and superior academic outcomes. But their growing use also stirs questions about the more profound cognitive ends of university education. Concerns and debates in particular have been growing over the extent to which AI supports cognitive engagement and the development of critical thinking skills as two essential discerners of the quality of higher education. With universities across the globe more and more to adopt or embed AI-enabled learning, insight into these cognitive effects is Both crucial and foundational informing evidence-based education and practice.

Cognitive engagement is the amount of mental effort and resources that students invest in the learning process. It

includes engagement, persistence with challenging problems, and cognitive strategies. Conventional wisdom says that the best learners are those who have been compelled to wrestle with difficult concepts, teased by competing points of view, and made to think through how they know what they know. AI technologies are primed to turn to facilitate this engagement, offering personalized feedback, real-time support, and content that is adapted to unique learning needs. Such as, pedagogy-based knowledge and reasoning enable to detect knowledge gaps, provides just-in-time motivational and cognitive support, personalized explanations, and keep students motivated and cognitively engaged. Along these lines, generative AI products can do so much to help students brainstorm, make sense of difficult texts, and break down some of the barriers to long-established teaching techniques they never really managed to get around to embracing. These features lend support to the notion that AI instruments, and likely future ones in this space, may be able to stimulate cognitive engagement (vs. the approach of focusing on study) by enabling learning tasks that were previously deemed too laborious to be practical.

Nevertheless, these same technological affordances bring with them a suite of challenges that may hinder students'

engagement. AI tools, including those that summarize readings, generate answers, or do analytical work, enable students to automate large swaths of the learning process and potentially lessen their engagement with educational material. Over reliance on AI assistance might also reduce intrinsic motivation and shallow cognitive struggle both of which are critical for long-term retention. The ease of access to fix and answers might dampen excitement for exploration, curiosity, and trial and errors among students. Hence the connection between cognitive engagement and taking up AI is not necessarily positive or negative in nature, but varies based on students' usage, type of AI tools used and learning context. This complexity calls for empirical research on how university students interact with AI in real-world learning contexts, and to what degree these interaction types enhance cognitive effort.

Critical thinking is a key attribute of the higher education experience, but it has now become the subject of a race-based query within US higher education with suggestions that such questioning of AI could be questioned-thinking. Critical thinking, the ability to critically analyze evidence, arguments, assumptions and reach well-supported conclusions, is important to success in academia and educational endeavours throughout life. AI products could even stimulate critical thinking by providing users with alternative viewpoints, enabling data analysis and facilitating higher levels of cognition. For instance, writing tools powered by the AI can detect logical gaps, suggest organizational improvements and assist students to think more critically. AI-based simulations and query systems allow teaching in complex, real-world situations that stimulate thinking. These kinds of educational tools, when used correctly, can challenge students to think more critically and to think on live television reactively.

Meanwhile, others say that AI curtails students' critical thinking since it makes them rely too much on outputs of algorithms instead of conducting their own analysis. Generative AI can produce high-quality answers that are likely to be plausible, thus possibly tempting students to acquire information with a 'just trust it' attitude. AI In some instances doing the work of constructing arguments, synthesizing sources, or even generating creative solutions: might students be deprived of some of the thinking that critical thinking requires. In addition, since many AI algorithms are non-transparent, which is also referred to as the "black box" problem, it is difficult for students to understand the underlying mechanism of outputs, and this obscured view hinders them

from conducting critical assessment of outputs. This tension speaks to a need to examine not if students use AI, but how they use it, and how that use shapes their higher-order thinking.

With AI being integrated into university education, its impact on cognitive engagement and critical thinking is increasingly important to understand for educators, policy makers, and universities. Several universities are competing to establish the guidelines for teaching, which are intended to foster AI-literacy; they are revising assessment practices in order to accommodate the new realities of learning with AI. However, the evidence base is conflicting and incomplete. Studies Available studies are heterogeneous in term of context, methods and conceptual frameworks, limiting the possibility to draw a clear conclusion. A portion of the literature argues that AI improves the effectiveness of learning, and leads to deeper thinking whereas other bodies of work point to decreasing levels of autonomy, critical thinking, and the possibility of skill degradation. Such inconsistencies highlight the necessity of a systematic inquiry that focuses on students' patterns of technology adoption in AI and their subsequent impacts on their cognitive engagement and critical thinking performance.

The present study intends to contribute to this gap by exploring what use university students make of AI tools in their academic writing, and how such use affects their cognitive processes. Situated within the discourses of digital learning and educational technology, this paper attempts to provide a more complex understanding of the cognitive implications of AI in HE. Considering the good and the bad, the results may be used to inform a balanced, responsible and pedagogically sound AI integration. Ultimately, it is not about to figure the "value" of AI, whether it is a good or bad thing, but to discover the situations in which it can enhance student learning and at the same time provide sufficient levels of intellectual challenge that sustain what is very unique of university education. The primary objective of this study is to examine the relationship between AI usage and critical thinking among university students, with particular emphasis on understanding whether the extent of AI use in academic activities is associated with students' critical thinking abilities.

II. LITERATURE REVIEW

The unprecedented growth in AI has had a profound impact on education, encompassing teaching, management, and learning.

In brief, AI are computer systems which are able to perform tasks that normally require human intelligence such as learning, thinking, and making decisions (Chen et al., 2020). AI and its application to education has progressed from simple CAI (computer-assisted instruction) to ITS (intelligent tutoring systems), AIE (adaptive instructional environments), LA (learning analytics), and CAs (conversational agents). AI is increasingly being used in educational administration to enable automatic scoring, plagiarism detection, processing of applications for admission, and monitoring of students' performance, and its use in teaching and learning to facilitate differentiated teaching immediate feedback, and personalized learning environments (Chen et al., 2020).

In content-based education, AI has proven to be very effective, especially in the field of foreign language education. The ICALL systems apply the techniques of artificial intelligence, including among others machine learning, natural language processing, and intelligent algorithms, to provide immediate feedback, tailored content, and flexible learning paths (Pokrivcakova, 2019). Such systems keep modeling learner progress and adapt instructional content in real-time, enabling very individualized learning experiences that exceed what is generally possible in traditional classrooms. Yet, the extent to which AI-enabled technologies can lead to positive pedagogical impact depends to a large degree on teachers' knowledge about these technologies and ability to effectively integrate them in their instruction.

Teacher readiness is among the one of the most determinative factors influencing the successful implementation of AI-based educational tools. Informal Sensemaking of AI: Educators knowledgeable about AI (but informally so) who were not learning about it in-service through PD, and who may be carrying misconceptions or a fragmented understanding (Velandar et al., 2024). The absence of clear policy directives and fuzzy descriptions of the curriculum also create obstacles for teachers who want to employ AI literacy in education. Emotional Reactions, Including Anxiety, Resistance and Privacy Concerns (Raising Related to Data Monitoring and Decision-Making via Algorithms) Are Also Barriers (Velandar et al., 2024). Macro-level quantification analysis also favors diverse AI-TPACK among educators. A 1,664 K–12 teachers sample showed particular gaps in content knowledge (CK) specific to AI and technological skills, but not in pedagogical knowledge (Yue et al., 2024). A series of regressions also shows that teachers' favorable attitudes

towards AI and their TPACK preparedness are positively significant, indicating that confidence, competence and intention to instruct of teachers are interrelated concepts.

These findings highlight the need for structured and ongoing AI-focused professional development (PD) for sustainable uptake in classrooms. For the student level, AI has brought enormous advantages to the higher education market, namely for the international student segment. Tools based on AI, including generative AI, chatbots, adaptive learning systems, and predictive analytics, improve educational support, engagement, and learning efficiency by providing tailored learning environments, real-time translation of language, automated writing feedback, and performance prediction (Wang et al., 2023). The technologies are instrumental in diminishing language barriers, cultural adjustment challenges, and academic pressure, which enables a more inclusive and equitable learning experience for global students.

However, the ethical and societal implications of integrating AI are still a matter of concern. Privacy violations, algorithmic bias, cultural insensitivity, and disparities in access to technological infrastructure have been documented (Wang et al., 2023). Teachers also voice concern over overly intrusive monitoring, diminished professional autonomy, and the opacity of algorithmic decision-making in AI-facilitated classrooms (Velandar et al., 2024). These are exacerbated by poor regulation and patchwork institutional AI policies. From the institution point of view, the adoption of a successful AI is not driven by a technological revolution but by a series of incremental and goal-oriented deployments. As with other industries where AI is being applied, AI applications can be classified as automation, cognitive insight, and cognitive engagement – such as in education, where they are used for administrative automation, learning analytics, and intelligent student support systems (Davenport & Ronanki, 2018).

When AI is employed as a means to enhance rather than replace human expertise, institutions are more likely to find success. This resonates with the perspective that AI should empower pedagogical decision-making and, at the same time, maintain ethical responsibility and the involvement of human judgement (Chen et al., 2020).

Taken together, the reviewed literature indicates three recurring themes. First, when used strategically, AI can lead to more personalized instruction, greater instructional efficiency,

and increased student motivation. Teacher readiness, to be more specific AI-related TPACK readiness, is still the most important facilitator of effective AI integration. Third, ethical conduct, professional training and comprehensive policy frameworks remain underdeveloped at the systemic level in education. Even though more and more scholars begin to pay attention to it, there are still big gaps of research in terms of the long-term impact of AI on higher order cognitive skills (e.g. critical thinking and problem solving) and learner autonomy, as well as the transformation of student-teacher relationship in AI-mediated learning environments. Thus, future investigations will need to be longitudinal, multidisciplinary and ethical to assess the full spectrum of the cognitive, institutional, and societal impacts of AI in education.

III. RESEARCH METHODOLOGY

This study followed a descriptive–correlational research design to understand how much students use AI tools and whether this use is related to their level of critical thinking. Primary data was collected using a structured questionnaire, which included a set of Likert-scale statements measuring two things: students’ AI usage behaviour, and their critical-thinking practices when using AI.

A total of 100 students from undergraduate and postgraduate programs participated in the study. They responded to 15 Likert-scale questions. After collecting the data, the responses were cleaned and analysed in several steps. Factor Analysis (Principal Factor Method with Varimax rotation) was used to identify the underlying patterns in students’ AI usage and

thinking behaviour. KMO and Bartlett’s tests were used to check if the data was suitable for factor analysis. Two clear factors emerged:

- AI Usage
- Critical Thinking / Responsible Use

Next, Cronbach’s Alpha was calculated to check the reliability of these factors. After that, correlation analysis was used to study the relationship between the two factors. Finally, simple linear regression was conducted to see whether AI usage could predict levels of critical thinking among students.

IV. FINDING AND ANALYSIS

Table 1: KMO Barlett Test

Test	Statistic	Value
Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy	KMO	0.780
Bartlett’s Test of Sphericity	Approx. Chi-Square (χ ²) df Sig. (p-value)	512.340 105 < 0.001

Sampling adequacy was examined using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett’s test of sphericity. The overall KMO value was 0.78, indicating good sampling adequacy. Bartlett’s test of sphericity was significant, $\chi^2 (105) = 512.34$, $p < .001$, confirming that the correlation matrix was not an identity matrix and that the data were suitable for factor analysis.

Table 2: Exploratory Factor Analysis (Principal Factor Method)

Questions	F1 (AI Usage)	F2 (Critical Thinking)	Communality (h ²)	Uniqueness (1–h ²)
AI enhances critical thinking	0.431	0.142	0.206	0.794
AI makes learning easier	0.392	0.159	0.179	0.821
Excessive AI use weakens thinking	–0.039	0.387	0.152	0.849
AI supports—not replaces—reasoning	0.196	0.595	0.393	0.607
I depend on AI tools	0.601	–0.181	0.393	0.607
I frequently use AI tools	0.811	–0.239	0.714	0.286
I have become reliant on AI	0.534	–0.314	0.383	0.617
I often use AI for assignments	0.695	–0.234	0.539	0.461
I rely on AI when short on time	0.571	0.010	0.326	0.674
I think independently before confirming AI	0.183	0.657	0.464	0.536
I use AI responsibly	0.365	0.645	0.548	0.452
I use AI tools carefully	0.704	–0.239	0.621	0.379
I question AI responses	0.443	0.286	0.278	0.722

My habit of deep thinking reduced	0.297	-0.210	0.132	0.868
I verify the accuracy of AI info	0.807	0.438	0.343	0.657
Timestamp (removed in analysis)	0.044	-0.191	0.038	0.962

Table 3: Factor Extraction Summary

Factor	Variance	Cumulative Variance	Proportion	Cumulative Proportion
F1	3.658	3.658	0.641	0.641
F2	2.052	5.709	0.359	1.000
Total	5.709	—	1.000	—

Authors' Computation

The exploratory factor analysis using the Principal Factor Method with Varimax rotation identified a clear two-factor structure explaining students' patterns of AI tool usage. The first factor, AI Adoption & Efficient Usage (F1), accounted for 64.10% of the common variance and consisted of items reflecting frequent, purposeful, and dependence-oriented use of AI tools for academic tasks (e.g., "I frequently use AI tools," "I rely on AI tools when I am short on time," "I often use AI for drafting or editing"). These items demonstrated strong loadings on Factor 1, indicating that students who actively use AI tools tend to employ them consistently across multiple academic activities. The second factor, AI Influence on Thinking / Cognitive Effects (F2), explained an additional 35.90% of the variance and captured students' perceptions regarding AI's impact on their critical and independent thinking. Items such as "I think independently before confirming AI-generated answers" and "AI makes learning easier without replacing the need for critical thinking" showed high loadings on Factor 2, whereas negatively worded items (e.g., "Excessive use of AI weakens analytical ability") also contributed to this dimension.

Communalities ranged from 0.13 to 0.71, indicating that most items moderately contributed to the factor solution, while uniqueness values suggested that some items were less strongly related to the underlying factors. Overall, the two extracted factors together explained the total common variance (100%), confirming a well-defined factor structure. These results indicate that students' interactions with AI tools in academic settings primarily reflect two dimensions: how extensively and efficiently they use AI, and how AI influences or aligns with their cognitive and critical-thinking behaviours. This structure provides a strong conceptual foundation for further reliability testing, correlation analysis, and regression modelling.

Table 4: Rotated Factor Loadings (Varimax Rotation)

Item (Short Description)	F1: AI Usage & Engagement	F2: Critical Thinking & Responsible Use
AI enhances critical thinking	0.352	0.287
AI makes learning easier	0.309	0.289
Excessive AI use weakens thinking	-0.107	0.347
AI should support (not replace) reasoning	0.201	0.626
I depend on AI tools	0.625	0.046
I frequently use AI tools	0.843	0.026
I have become dependent on AI	0.601	-0.102
I often use AI	0.733	0.030
I rely on AI when short on time	0.579	0.039
I think independently when using AI	0.096	0.701
I use AI responsibly	0.111	0.733
I use AI tools for assignments	0.770	0.033
I usually question AI responses	0.312	0.425
My deep thinking habit has reduced	0.316	-0.095
I verify AI information	0.455	0.589
Timestamp (not included in analysis)	0.109	-0.163

Authors' Computation

Factor	F1	F2
F1	1.000	0.000
F2	0.000	1.000

Authors' Computation

Two factors were extracted and rotated using the orthogonal Varimax method. Factor 1 represents AI Usage & Engagement, with strong loadings from items related to frequent, dependent, and task-based use of AI tools. Factor 2 captures Critical Thinking & Responsible AI Use, with strong loadings from items reflecting independent thinking, judgement, and responsible evaluation of AI outputs. The factors were uncorrelated, consistent with Varimax rotation.

Table 5: Cronbach Alpha

Factor	Description	No. of Items	Cronbach's Alpha (α)	Reliability Level
Factor 1	AI Usage	6	0.684	Acceptable
Factor 2	Critical Thinking	4	0.546	Moderate

Authors' Computation

Alpha values between 0.60–0.70 are considered acceptable for exploratory research; values between 0.50–0.60 are tolerable for attitudinal constructs with mixed wording

Cronbach's Alpha was computed to assess the internal consistency of the factors extracted through exploratory factor analysis. Factor 1 (AI Adoption & Efficient Usage) demonstrated acceptable reliability with a Cronbach's Alpha of 0.684, indicating that the six items measure a consistent construct. Factor 2 (AI Influence on Thinking / Cognitive Effects) produced an Alpha of 0.546, which reflects moderate but tolerable internal consistency given the attitudinal nature of the items and the presence of a negatively worded statement. Overall, the reliability results support the use of the extracted factors for further statistical analysis.

Table 6: Correlation Table Using Raw Mean Scores

Variable	AI Usage (F1_raw)	Critical Thinking (F2_raw)
AI Usage	1.000	0.514
Critical Thinking	0.514	1.000

Authors' Computation

H01: There is no significant relationship between AI Usage and Critical Thinking.

There is a moderate positive correlation between AI Usage and Critical Thinking ($r = 0.514$, $p < .001$).

This indicates that students who use AI more frequently and efficiently tend to report stronger critical-thinking behaviours when interacting with AI-generated information. The null hypothesis is therefore rejected.

Table 7: Regression Analyses Using Raw Mean Scores

Predictor	B	SE(B)	β	t	p
AI Usage (F1_raw)	0.4315	0.0728	0.514	5.93	0.001

Constant	1.6585	0.278	—	5.97	0.001
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Authors' Computation

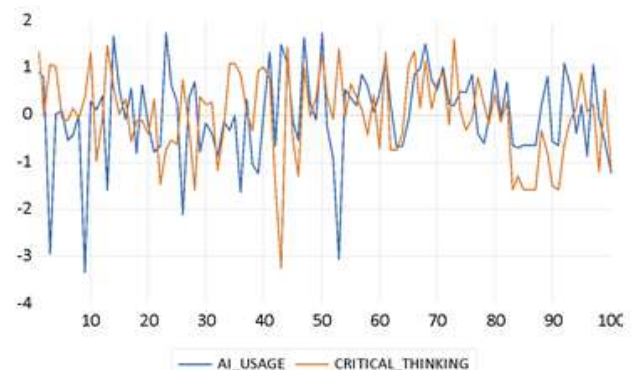
Model Summary:

- $R^2 = 0.264$
- Adjusted $R^2 = 0.257$
- $F(1,98) = 35.15$, $p < .001$
- Outcome: Critical Thinking (F2_raw)

H02: AI Usage doesn't significantly predict Critical Thinking. A simple linear regression revealed that AI Usage significantly predicts Critical Thinking,

$F(1, 98) = 35.15$, $p < .001$, explaining 26.4% of the variance ($R^2 = .264$).

AI Usage was a significant positive predictor ($\beta = 0.514$, $p < .001$), meaning that greater adoption and efficient use of AI tools is associated with higher levels of independent and responsible thinking among students. Null Hypothesis is rejected.



We used raw mean scores because EVIEWS factor scores are standardized (mean ≈ 0), which removes the natural differences in how students responded. As a result, correlations and regression become inaccurate. Raw means preserve the real response patterns, giving correct and meaningful results.

V. CONCLUSION

The study shows that AI has become an important part of students' academic work. From the findings, it is clear that students use AI tools frequently—for understanding topics, completing assignments, and saving time. Factor analysis helped identify two major patterns in behaviour: how students use AI and how they think independently when using it.

The results indicate a moderate, positive relationship between AI usage and critical thinking. This means students who use AI more regularly also tend to think more responsibly and critically while using these tools. The regression analysis confirmed that AI usage significantly predicts critical-thinking behaviour. In simple terms, students who use AI tools well are more likely to question, verify, and think independently rather than blindly accepting AI-generated answers.

Therefore, the study suggests that AI—when used properly—can support students' thinking skills instead of reducing them. It highlights the importance of teaching students how to use AI responsibly so they continue to develop good judgement and independent thinking.

Limitations

Although the study provides useful insights, it has a few limitations:

1. **Small sample size:** Only 100 students participated, which may not fully represent all students in higher education.
2. **Self-reported data:** The questionnaire relied on students' honesty and self-perception, which can sometimes be biased or inaccurate.
3. **Cross-sectional design:** Data was collected at one point in time, so we cannot see how AI usage or critical thinking changes over time.
4. **Limited variables:** The study focused only on AI usage and critical thinking. Other important factors—such as study habits, subject area, or digital literacy—were not included.
5. **No qualitative insights:** The study did not include interviews or open-ended questions that could explain why students use AI in certain ways.
6. **Different types of AI tools:** Students use many kinds of AI tools (ChatGPT, grammar tools, summarizers, etc.), but the study did not analyse these separately.

Even with these limitations, the study gives a meaningful understanding of how AI impacts students' academic behaviour and thinking patterns.

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