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Critical thinking and knowledge in the age of AI

Pensamiento crítico y conocimiento en la era de la IA

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Abstract

The growth of artificial intelligence (AI) in higher education has reshaped information management and knowledge construction processes, posing novel challenges between automation and intellectual autonomy. In this context, the objective of this research is to analyze the relationship between university students' critical thinking and knowledge construction. This quantitative, non-experimental, cross-sectional study with a correlational-causal scope was applied to a sample of 200 undergraduate students from a Peruvian university. The Critical Thinking Questionnaire (CPC-2) and the COLLES scale were used, applying Spearman's rho coefficient. The results showed a very high positive correlation between overall critical thinking and university knowledge construction (Rho = 0.999; $p < 0.05$), with similar results in the substantive and dialogic dimensions. These findings indicate that higher levels of critical thinking are associated with more robust knowledge construction processes in AI-mediated contexts, highlighting the need to strengthen critical thinking in university education.

Keywords: critical thinking; knowledge; artificial intelligence; higher education.

Resumen

El crecimiento de la inteligencia artificial (IA) en la educación superior ha reconfigurado los procesos de gestión informativa y construcción de conocimiento, planteando novedosos desafíos entre la automatización y la autonomía intelectual. En este contexto, el objetivo de la presente investigación es analizar la relación entre el pensamiento crítico de los estudiantes universitarios y la construcción del conocimiento. Es un estudio cuantitativo, de diseño no experimental, de corte transversal y alcance correlacional-causal, aplicado a una muestra de 200 estudiantes de pregrado de una universidad peruana. Se utilizó el Cuestionario de Pensamiento Crítico (CPC-2) y la escala COLLES, aplicando el coeficiente Rho de Spearman. Los resultados evidenciaron una correlación positiva muy alta entre el pensamiento crítico global y la construcción del conocimiento universitario (Rho = 0.999; $p < 0.05$), con resultados similares en las dimensiones sustantiva y dialógica. Estos hallazgos indican que niveles más elevados de pensamiento crítico se asocian con procesos de construcción del conocimiento más sólidos en contextos mediados por IA, resaltando la necesidad de fortalecer el pensamiento crítico en la formación universitaria.

Palabras clave: pensamiento crítico; conocimiento; inteligencia artificial; educación superior.

Introduction

Higher education today is undergoing a structural transformation driven by the growing presence of artificial intelligence (AI) as a tool applied to tasks traditionally associated with human cognition, like deductive reasoning and problem-solving among them. In this evolving landscape, AI has reshaped how students access information, construct knowledge, and develop foundational learning skills. This represents a substantive shift in which critical thinking increasingly functions as a conscious, reflective process, one that balances technology with reasoned and ethical human interaction. Dewey (1993) framed critical thinking as an intellectual practice enabling well-founded problem resolution, while Ennis (1985) emphasized the capacity to exercise sound judgment in evaluating what one accepts as true. In a similar vein, Paul and Elder (2019) argued that critical thinking must rest upon open-mindedness, conceptual clarity and precision, relevance, depth, and reasoning rigor.

Within the digitalized university ecosystem, these perspectives gain further traction when coupled with socio-constructivist theories (Vygotsky, 1978; Freire, 1970), which underscore the value of shared reflection, dialogue, and each student's cognitive autonomy as cornerstones of meaningful learning. In other words, learning entails more than passively receiving information; it calls for semantic scaffolding built through interaction, problematization, and the student's intellectual and ethical commitment.

In this study, critical thinking is approached as a dual construct integrating substantive and dialogic dimensions, consistent with the framework of Critical Thinking Questionnaire (CPC-2) by Santiuste (2001). The substantive dimension refers to the ability to evaluate the validity of information and to distinguish well-grounded arguments from those lacking foundation, an aspect Facione (1990) identified as encompassing essential cognitive skills. The dialogic dimension, in turn, involves the capacity to examine and weigh divergent perspectives. As Lipman (2003) contended, knowledge construction requires deliberative dialogue and emerges from interaction with others and from balancing one's own reflections with those of peers.

At present, a central challenge lies in reconciling AI implementation with the strengthening of students' critical thinking through pedagogical models that encourage content evaluation and deliberative practice, models that ensure AI serves as a tool rather than a substitute for human judgment (Moustaghfir & Brigui, 2024). Although some authors, Boubker (2024) and El-Ashry et al. (2025), for instance, report that ChatGPT use can positively correlate with knowledge construction outcomes in higher education, particularly when students employ it for self-directed learning, others identify critical risks. Gerlich (2025) and Khatri and Karki (2023), for example, caution that less experienced students may become overwhelmed by the automation of intellectual tasks, leading to technological dependence, weakened creativity, and diminished reflective effort.

These concerns are echoed in studies by Essien et al. (2024), Malik et al. (2023), Lamberti et al. (2025), and Nasr et al. (2025), who converge on the observation that the proliferation of generative AI solutions in university education has introduced new axiological and epistemological dilemmas. While AI tools (text generators and chatbots) can bolster initial learning phases such as comprehension and exploration, they may also undermine autonomous judgment, as some students accept AI-generated responses without further questioning, resulting in unfounded decision-making.

Nevertheless, despite these drawbacks, evidence from Naatonis et al. (2024), Mayasari et al. (2024), and Park and Kim (2025) indicates that integrating AI tools into problem-based learning models, personalized curricula,

or clinical simulations can significantly enhance critical thinking skills, academic performance, and digital literacy. Similarly, Ruiz-Rojas et al. (2024), Lara Borja et al. (2025), and Nasr et al. (2025) suggest that reflective AI use benefits key phases of knowledge construction, as long as students remain actively engaged and self-regulated. Chaparro-Banegas et al. (2024) likewise show that certain formative experiences (field visits, seminars, and AI-focused workshops) strengthen critical thinking. In parallel, Yücel (2025) documents sustained growth in critical thinking research linked to learning digitization, highlighting the need for interdisciplinary theoretical frameworks that integrate technology, pedagogy, and ethics. This reinforces the notion that critical thinking is not confined to logical reasoning but constitutes an ethical and intellectual practice oriented toward deep understanding, information evaluation, and responsible decision-making in digitalized learning environments (Ricra et al., 2025).

In this context, the present research aims to analyze the relationship between critical thinking and knowledge construction among students at a Peruvian university, situated within AI-mediated learning settings. Specifically, the study seeks to describe levels of critical thinking in its substantive and dialogic dimensions, describe levels of knowledge construction among university students, determine the relationship between overall critical thinking and knowledge construction, and examine the relationship between both critical thinking dimensions and knowledge construction.

Methodology

A quantitative research approach was adopted, with a non-experimental, cross-sectional design and a correlational scope. Data were collected at a single point in time, without manipulating the study variables, for the purpose of analyzing the relationship between critical thinking and knowledge construction in university students (Hernández-Sampieri & Mendoza, 2018).

The sample consisted of 200 undergraduate students from a private university in Lima, Peru. All participants were active users of generative AI tools and digital learning ecosystems; participation was voluntary and conducted in accordance with the ethical protocols for academic research.

The survey technique was employed, using two psychometric instruments. The Critical Thinking Questionnaire (CPC-2) was administered to measure the critical thinking variable; it comprised 18 items organized into substantive and dialogic dimensions. Knowledge construction was assessed using the COLLES scale (Constructivist On-Line Learning Environment Survey), which consists of 24 items distributed across six dimensions: professional relevance, critical reflection, interactivity, tutor support, peer support, and interpretation within technological environments.

Statistical processing was carried out using SPSS version 27. The procedure began with calculation of Cronbach's alpha coefficient to verify the internal consistency of the scales, followed by the Kolmogorov-Smirnov goodness-of-fit test, which revealed non-normal data distribution ($p < 0.05$). Consequently, Spearman's rho non-parametric correlation coefficient was applied, with a 95% confidence level to determine statistical significance.

Results

The findings are presented below in accordance with the general and specific objectives of the study. Table 1 displays continuous numerical values regarding the level of critical thinking and knowledge construction among participating university students.

Table 1

Descriptive statistics for critical thinking and knowledge construction (N = 200)

Variable	M	SD	Min.	Max.
Substantive critical thinking	3.64	1.03	1.33	4.78
Dialogic critical thinking	3.67	1.03	1.44	4.89
Overall critical thinking	3.66	1.03	1.39	4.83
Knowledge construction: relevance	3.74	1.06	1.5	5
Knowledge construction: critical reflection	3.7	1.04	1.25	5
Knowledge construction: interactivity	3.72	1.05	1.5	5
Knowledge construction: tutor support	3.71	1.06	1.25	5
Knowledge construction: peer support	3.68	1.02	1.5	5

Knowledge construction: interpretation	3.71	1.09	1.25	5
Overall knowledge construction	3.71	1.05	1.38	5

Note. M = mean; SD = standard deviation

As shown in Table 1, on a 1-to-5 scale, university students exhibited medium-to-high levels of both critical thinking and knowledge construction. The mean score for overall critical thinking was 3.66 (SD = 1.03), with very similar values for its substantive (M = 3.64) and dialogic (M = 3.67) dimensions. In practical terms, this indicates that, on average, students analyze information, evaluate arguments, and consider alternative viewpoints with a frequency falling between "sometimes" and "often."

Similarly, overall knowledge construction (COLLES) averaged 3.71 (SD = 1.05). This result suggests that students perceive themselves as building knowledge relatively solidly within their AI-mediated learning environments, with opportunities for critical reflection, interaction, and support from both instructors and peers.

Table 2

Levels of critical thinking and knowledge construction (N=200)

	Overall critical thinking		Overall knowledge construction	
Level	**n**	**%**	**n**	**%**
Low	28	14.0	28	14.0
Medium	72	36.0	52	26.0
High	100	50.0	120	60.0
Total	200	100.0	200	100.0

Note. Levels were established based on global scores on a 1-to-5 scale

Table 2 classifies participants into low, medium, and high levels for overall critical thinking and overall knowledge construction. Half of the sample (50%, n = 100) demonstrated a high level of critical thinking, while the majority (60%) fell into the high category for knowledge construction. These findings indicate that, on the whole, students think critically and construct knowledge at relatively high levels, suggesting a university context in which reflection, interpretation, and active participation in learning are reasonably present, although a minority subgroup would benefit from targeted support to further develop these competencies.

Table 3

Spearman's correlations between critical thinking and knowledge construction (N=200)

Critical thinking variable	Knowledge construction variable	Spearman's Rho	Sig. (two-tailed)
Overall critical thinking	Overall knowledge construction	0.999	< 0.001
Substantive dimension	Overall knowledge construction	0.996	< 0.001
Dialogic dimension	Overall knowledge construction	0.998	< 0.001

Note. Spearman's Rho coefficient was used due to non-normality of the data. All correlations were statistically significant at p < 0.001

Table 3 reports the relationships between variables, revealing a very high positive correlation between critical thinking and knowledge construction among university students within AI-mediated learning environments. Overall critical thinking was strongly associated with overall knowledge construction (Rho = 0.999), as were the substantive and dialogic dimensions (Rho = 0.996 and Rho = 0.998, respectively). This result supports the assertion that as students' critical thinking abilities increase, so too does the quality of their knowledge construction in AI-mediated formative experiences. The table addresses the general objective by empirically demonstrating that critical thinking constitutes a key factor in university knowledge construction processes in the age of artificial intelligence.

Table 4
Joint distribution of critical thinking and knowledge construction levels (N = 200)

Critical thinking level	Overall knowledge construction level			Total
	Low	Medium	High	
Low	28 (14,0 %)	0 (0,0 %)	0 (0,0 %)	28 (14,0 %)
Medium	0 (0,0 %)	52 (26,0 %)	20 (10,0 %)	72 (36,0 %)
High	0 (0,0 %)	0 (0,0 %)	100 (50,0 %)	100 (50,0 %)
Total	**28 (14,0 %)**	**52 (26,0 %)**	**120 (60,0 %)**	**200 (100,0 %)**

Note. Percentages were calculated over the total sample (N = 200)

Table 4 illustrates the correspondence between critical thinking levels and knowledge construction levels among university students. All participants with low critical thinking (14.0%) also exhibited low knowledge construction. The medium critical thinking group (36.0%) was distributed across medium (26.0%) and high (10.0%) knowledge construction levels, with no presence in the low category. These data reveal a nearly "perfect" alignment: higher critical thinking consistently corresponded to higher knowledge construction. This finding bears directly on the study's general objective and, in turn, underscores the necessity for higher education institutions to align their curricular designs, learning experiences, and institutional AI policies with strategies that catalyze critical thinking and guard against cognitive dependence on automated information use.

The results thus highlight the need for universities to intentionally integrate critical thinking development into their AI-related curricular and policy frameworks.

Discussion

The findings revealed medium-to-high levels of critical thinking and knowledge construction among the participating university students. Overall critical thinking averaged 3.66, while overall knowledge construction reached a mean of 3.71, indicating favorable appraisals of both variables in AI-mediated learning environments. These outcomes align with the conception of critical thinking by Padmanabha (2018), who perceives critical thinking as a cognitive activity enabling knowledge transfer across disciplines, and they also resonate with the report of Boubker (2024) that ChatGPT use is associated with improved learning outcomes in higher education, particularly when employed for content deepening rather than merely for quick answers.

Similarly, Naatonis et al. (2024) demonstrated that a problem-based and gamified learning model integrated with the ChatGPT API significantly enhances university students' critical thinking capacity. This parallels the present study's results, in that AI can serve as a stimulus for critical thinking when embedded within structured inquiry activities. Mayasari et al. (2024) likewise found that combining AI-based learning tools with personalized curricula correlated positively and significantly with critical thinking skills. This suggests that technology alone does not guarantee favorable cognitive outcomes; rather, its effectiveness depends on articulation with curricular design, pedagogical mediation, and active student participation.

The study also identified very high positive correlations between overall critical thinking and overall knowledge construction (Rho = 0.999; $p < 0.001$), as well as between the substantive and dialogic dimensions of critical thinking and knowledge construction (Rho = 0.996 and Rho = 0.998, respectively). These findings support the view that knowledge construction in AI-mediated contexts depends not only on access to technological tools but also on students' capacity to analyze, compare, interpret, and critically evaluate information. In this regard, the results are consistent with Ruiz-Rojas et al. (2024) and Nasr et al. (2025), who contend that AI can enhance learning when used actively, collaboratively, and reflectively, rather than as a substitute for academic judgment.

Other studies have identified positive or mixed impacts on critical thinking development. Melisa et al. (2025), for instance, emphasized that AI's effects in higher education hinge on how students exercise judgment, evaluation, and verification of AI-generated information. Similarly, Howard and Ulferts (2025) and Slimi (2023) observed that AI is reshaping higher education, yet its benefits in terms of learning and complex competency development materialize only when accompanied by pedagogical practices oriented toward reflection and critical thinking.

However, AI's effects on higher education are not uniformly positive. Nasr et al. (2025) cautioned that while tools like ChatGPT may support exploration and integration phases within cognitive presence, they do not necessarily strengthen problem-solving, a dimension associated with sound decision-making and transformative action. In this sense, uncritical AI use can foster dependence and promote prefabricated or superficial responses. Along similar lines, Molerov et al. (2020) argued that indiscriminate use of digital resources can induce errors due to incomplete, biased, or contradictory information.

Finally, Malik et al. (2023) documented student concerns about ethical academic writing practices and the potential effects of AI on creativity and critical thinking. Khatri and Karki (2023) further warned that AI tools pose risks to academic integrity and the development of independent judgment. These concerns echo those of Gerlich (2025), who contended that a lack of moderation in AI use can encourage cognitive offloading and reduce autonomous analytical capacity. The results of the present study accordingly reinforce the imperative to promote critical, ethical, and pedagogically oriented AI use in university education.

Conclusions

A positive, medium-to-high association emerged between critical thinking and AI use (50% + 36% = 80%), suggesting that higher levels of critical thinking, in both of its dimensions, correspond to higher reported levels of knowledge construction. This indicates that critical thinking functions as a structuring factor in how students transform information into meaningful knowledge within educational ecosystems that include AI. Moreover, formative experiences appear to have developed students' analytical, evaluative, and perspective-contrasting abilities to a considerable degree, although a minority subgroup (14%) continues to require targeted support to strengthen these skills.

Students also perceived their learning environments as relevant, interactive, and conducive to reflection, suggesting that technological mediation, specifically AI, is being integrated into educational experiences that favor active participation, interpretation, and exchange with instructors and peers.

Notably, beyond the very high positive correlations observed, students with high critical thinking were concentrated exclusively in high levels of knowledge construction, whereas those with low critical thinking were located solely in low knowledge construction levels. This pattern reinforces the idea that critical thinking is a necessary condition for AI-mediated environments to translate into genuine learning processes rather than superficial technology use.

From this perspective, the correlations found in this study between critical thinking and knowledge construction should not be interpreted as an automatic effect of AI use, but rather as an indicator that when students exercise critical thinking, technology is integrated in a "healthy" manner into knowledge construction. Finally, in line with the study's results, the need to continue developing curricular and didactic strategies that strengthen critical, reflective, and ethical use of artificial intelligence in university education is underscored. In educational practice, this implies designing AI-based activities that require students, for example, to compare AI outputs with consulted literature, detect errors, improve arguments, or justify why an AI response is accepted or rejected, thereby compelling students to activate their critical thinking rather than merely copy.

In synthesis, the mere presence of artificial intelligence does not explain the quality of knowledge construction; rather, quality is contingent upon the student's level of critical thinking, which makes the difference in how AI tools are incorporated into cognitive and formative processes.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this scientific article.