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ARTICLE

Generative Artificial Intelligence Use and Critical Thinking in Higher Education

Uso de la Inteligencia Artificial Generativa y el Pensamiento Crítico en la Educación Superior

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ABSTRACT

The integration of Generative Artificial Intelligence (GenAI) into higher education has transformed academic practices and raised concerns regarding its relationship with critical thinking. This study aimed to describe patterns of GenAI use and analyze their relationship with critical thinking among higher education students in Zacatecas, Mexico. The research was framed within the positivist paradigm, followed the hypothetical-deductive method, and adopted a quantitative approach with a non-experimental, descriptive-correlational, cross-sectional design. The sample consisted of 393 students selected through non-probability convenience sampling. Data were collected through a 21-item structured questionnaire administered via Google Forms and analyzed using descriptive and inferential statistics, including frequencies, percentages, chi-square tests, and Spearman correlations. The findings showed that GenAI use was predominantly occasional, mainly through ChatGPT and Gemini, for idea generation, concept explanation, and information summarization. Students reported critical practices such as response verification, coherence analysis, and error detection. Weak-to-moderate positive associations were identified between frequency of GenAI use and both perceived improvement in critical thinking and learning support. The study concluded that GenAI can support learning when used reflectively; however, its educational value depends on ethical guidance, institutional policies, and pedagogical strategies that promote critical and responsible use.

KEYWORDS: ChatGPT, critical thinking, Generative Artificial Intelligence, Higher education, Zacatecas.

RESUMEN

La integración de la Inteligencia Artificial Generativa (IAG) en la educación superior ha transformado las prácticas académicas y ha generado preocupaciones sobre su relación con el pensamiento crítico. El estudio tuvo como objetivo describir los patrones de uso de la IAG y analizar su relación con el pensamiento crítico en estudiantes de educación superior de Zacatecas, México. La investigación se enmarcó en el paradigma positivista, bajo el método hipotético-deductivo, con enfoque cuantitativo, diseño no experimental, tipo descriptivo-correlacional y corte transversal. La muestra estuvo conformada por 393 estudiantes seleccionados mediante muestreo no probabilístico por conveniencia. Los datos se recolectaron mediante un cuestionario estructurado de 21 ítems aplicado a través de Google Forms y se analizaron con estadística descriptiva e inferencial, incluyendo frecuencias, porcentajes, pruebas de chi-cuadrado y correlaciones de Spearman. Los resultados evidenciaron un uso predominantemente ocasional de la IAG, principalmente mediante ChatGPT y Gemini, para la generación de ideas, explicación de conceptos y síntesis de información. Los estudiantes reportaron prácticas críticas como verificación de respuestas, análisis de coherencia y detección de errores. Se identificaron asociaciones positivas débiles a moderadas entre la frecuencia de uso de la IAG, la mejora percibida del pensamiento crítico y el apoyo al aprendizaje. Se concluyó que la IAG puede apoyar el aprendizaje cuando se usa reflexivamente; sin embargo, su valor educativo depende de la orientación ética, las políticas institucionales y las estrategias pedagógicas que promuevan un uso crítico y responsable.

PALABRAS CLAVE: ChatGPT, educación superior, Inteligencia Artificial Generativa, pensamiento crítico, Zacatecas.

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Introduction

The integration of Generative Artificial Intelligence (GenAI) into higher education transforms academic practices and creates new possibilities for learning, writing, research, and conceptual understanding. Students increasingly use these tools to save time, generate ideas, explain complex concepts, summarize information, and support academic production. Recent studies report that GenAI use varies across contexts, ranging from 33% in Mexican samples to 92% among British students, with intermediate levels in Latin American populations (García, 2023; Freeman, 2025; Solís et al., 2024; Morales et al., 2025). These data show that GenAI is becoming a relevant resource in university learning environments, although its educational value depends on how students use and evaluate its responses.

Despite these benefits, GenAI use also raises concerns related to dependency, plagiarism, inaccurate information, reduced cognitive effort, and the weakening of critical thinking. Students may accept generated content without verifying sources, evaluating coherence, or identifying possible errors and biases. This situation is especially relevant in higher education, where analytical reasoning, academic integrity, and autonomous learning are essential components of professional training. In this regard, previous research warns that the uncritical use of GenAI may limit students' capacity to evaluate information and construct independent arguments (Cotton et al., 2024; García, 2023; Contractor & Reyes, 2025).

The literature proposes different responses to these challenges. Some studies emphasize ethical integration, institutional policies, and teacher and student training to promote responsible use of GenAI (Baek et al., 2024; Freeman, 2025; Cabeza-Rodríguez, 2025). Others examine factors associated with adoption, such as habit, motivation, satisfaction, gender, trust, and digital divides (Gil-Vera, 2024; Sergeeva et al., 2025; Downey et al., 2025; Galindo-Domínguez et al., 2024). However, many of these studies have been conducted in contexts with greater technological access or broader institutional regulation, which limits their direct applicability to Mexican higher education settings marked by institutional diversity and unequal digital conditions.

In Mexico, GenAI adoption is still developing without sufficient institutional guidance in many educational contexts, which increases the need to examine how students use these tools and how such use relates to critical thinking. In the state of Zacatecas, limited research has addressed the specific patterns of GenAI use among higher education students and their relationship with practices such as verification, error detection, and reflective evaluation of information. Therefore, this study aims to describe the patterns of GenAI use and analyze their relationship with critical thinking among higher education students in Zacatecas, Mexico. The research is guided by the following question: What are the patterns of GenAI use and their relationship with critical thinking among higher education students in Zacatecas?

Methodology

To address the stated objective, the study was framed within the positivist paradigm, which assumes that educational phenomena can be examined through empirical observation, measurement, and systematic analysis (McMillan & Schumacher, 2006). The research followed the hypothetical-deductive method, as it sought to empirically examine the relationship between previously defined variables: Generative Artificial Intelligence use and critical thinking (Hernández-Sampieri & Mendoza, 2018). A quantitative approach was adopted because the study measured, described, and analyzed variables through numerical data and statistical procedures (Hernández-Sampieri & Mendoza, 2018). The design was non-experimental, since the variables were not deliberately manipulated but observed in their natural context (McMillan & Schumacher, 2006). The study was descriptive-correlational in scope, as it described patterns of GenAI use and examined their association with critical thinking. It was also cross-sectional, because the data were collected at a single point in time.

Based on the research problem, objective, and theoretical background, three hypotheses were formulated. H1 proposed that the frequency of GenAI use would be positively and significantly associated with students' perceived improvement in

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critical thinking. H2 proposed that the frequency of GenAI use would be positively and significantly associated with the detection of errors, biases, or incomplete information in GenAI-generated responses. H3 proposed that the frequency of GenAI use would be positively and significantly associated with the implementation of corrective or verification actions after identifying potentially inaccurate information. These hypotheses were examined through Spearman's rank correlation analyses, consistent with the ordinal nature of the variables and the descriptive-correlational design of the study.

The target population consisted of higher education students enrolled in participating institutions in the state of Zacatecas, Mexico. A non-probability convenience sample of 393 students was recruited on the basis of accessibility and voluntary participation. The study included students from the "Gral. Matías Ramos Santos" Rural Normal School, the Autonomous University of Zacatecas, the Loreto Institute of Technology, the "Salvador Varela Reséndiz" Experimental Normal School, and the "Manuel Ávila Camacho" Distinguished Normal School. The final sample comprised 299 students from Normal Schools (76.1%), 61 from the Autonomous University (15.5%), and 33 from the Technological Institute (8.4%). Data were collected between February and March 2026 through an online questionnaire administered via Google Forms.

Participants were eligible if they were actively enrolled in one of the participating higher education institutions, had used at least one GenAI tool during their academic trajectory, and voluntarily provided informed consent. Responses were excluded when the questionnaire was incomplete or when respondents were not actively enrolled during the data-collection period. Because participants were selected through convenience sampling and the institutional distribution was unequal, the sample was not assumed to be statistically representative of the entire higher education student population of Zacatecas. Accordingly, inferential findings were interpreted within the limits of the participating sample and were not used to claim population-level generalization.

The technique used for data collection was a survey, and the instrument was a self-administered structured questionnaire designed in Google Forms. The questionnaire consisted of 21 items: 19 closed-ended questions, including multiple-choice, Likert-type, and dichotomous items, and two open-ended questions used as complementary information. The instrument was organized into three analytical dimensions: (1) sociodemographic variables (age, gender, academic program, and type of institution); (2) GenAI-assisted writing usage patterns, which included level of knowledge, tools used (ChatGPT, Gemini, Copilot, among others), frequency of use, academic activities performed, citation practices, and knowledge of institutional regulations; and (3) critical thinking practices associated with the evaluation, verification, and correction of information generated by AI-powered tools, including attitudes toward the responses, assessment of reliability, error detection, corrective actions, perception of improvement in analytical ability, perceived impact on learning, guidance received, and intention to use them in the future.

Instrument quality was examined through pilot testing and expert review. First, the questionnaire was pilot-tested with 30 higher education students who were not included in the final sample to evaluate item clarity, completion time, response-option adequacy, and technical functionality. Based on the pilot results, minor adjustments were made to item wording and sequencing. Second, three specialists in higher education and educational technology independently evaluated the relevance, clarity, coherence, and alignment of the items with the research objectives and analytical dimensions, reaching more than 90% agreement regarding the final version. Because the questionnaire comprised heterogeneous sociodemographic, nominal, ordinal, and multiple-choice items rather than a single psychometric scale, a global internal-consistency coefficient was not considered appropriate.

Data analysis combined descriptive and inferential statistical procedures according to the measurement level and distributional characteristics of the variables. Absolute frequencies and percentages were calculated to characterize sociodemographic attributes, GenAI usage patterns, academic purposes, attitudes toward generated responses, error-detection practices, verification behaviors, and perceived effects on learning and critical thinking. Pearson's chi-square tests of

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independence were used to examine associations between categorical variables across institutional groups when the expected-frequency assumptions were satisfied. For contingency tables in which more than 20% of the expected cell frequencies were below five, the Fisher-Freeman-Halton exact test with Monte Carlo estimation was applied. Statistical significance was set at $p < .05$, and Cramér's V was reported as an effect-size measure for institutional comparisons. Spearman's rank correlation coefficient (ρ) was used to test the hypotheses concerning associations between frequency of GenAI use and ordinal indicators of perceived improvement in critical thinking, error detection, and corrective or verification actions. Correlation magnitude and statistical significance were interpreted separately to avoid equating statistical significance with the practical or educational relevance of the observed associations.

Responses to the two open-ended questions were analyzed exclusively as complementary descriptive evidence and did not constitute an independent qualitative phase. Responses were reviewed, grouped according to recurring semantic similarities, and summarized into descriptive categories related to perceived benefits, risks, and recommendations for GenAI use. Frequencies of mentions were used only to support interpretation of the quantitative findings and were not treated as evidence derived from a formal qualitative design. This procedure preserved the quantitative orientation of the study while allowing participants' open-ended responses to provide contextual information relevant to the interpretation of the survey results.

Regarding research ethics, the study followed ethical principles for educational research involving human participants (McMillan & Schumacher, 2006). Participation was voluntary, anonymous, and confidential. An informed consent statement was provided at the beginning of the questionnaire, explaining the study's objective, the academic use of the data, and the absence of associated risks. No personally identifiable information was collected, and participants were informed of their right to withdraw at any stage without consequences. In accordance with the applicable institutional regulations, the study was exempt from formal ethics committee review. All participants provided informed consent before completing the questionnaire.

The authors further declare that the generative artificial intelligence tool Grok, the free version as of February 2026, developed by xAI, was used only in a limited and auxiliary manner for language refinement and writing support. This use did not replace the authors' intellectual contribution and was declared in accordance with principles of transparency, accountability, and academic integrity established in the Heredia Declaration (Penabad-Camacho et al., 2024) and the editorial policies.

Results

The results showed that GenAI was used primarily as a complementary academic resource among the participating higher education students, with ChatGPT and Gemini emerging as the most frequently reported tools. Occasional use predominated, particularly for idea generation, concept explanation, and information summarization. Students also reported engaging in practices associated with critical evaluation, including response verification, coherence analysis, error detection, and consultation of alternative sources. Inferential analyses identified statistically significant but weak-to-moderate associations between frequency of GenAI use and selected indicators of perceived critical thinking and verification behavior. These findings describe associations within the participating sample and do not establish causal effects of GenAI use on critical thinking.

Sample Characteristics

The sample consisted of 393 higher education students from the state of Zacatecas, distributed across five institutions: "Gral. Matías Ramos Santos" Rural Normal School, the Autonomous University of Zacatecas, the Loreto Institute of Technology, the "Salvador Varela Reséndiz" Experimental Normal School, and the "Manuel Ávila Camacho" Distinguished Normal School. In terms of age, the distribution was as follows: 18 years old (30.8%), 20 years old (22.9%), 19 years old (16.8%), 21 years old (15.3%), 23 years old or older (8.9%), and 22 years old (5.3%). Regarding

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gender, 58.8% of the participants identified as female, 39.7% as male, 0.8% as "other", and 0.8% preferred not to disclose their gender. As for academic programs, 84.7% were pursuing a bachelor's degree and 15.3% an engineering degree.

Knowledge and Patterns of GenAI Use

Table 1

Knowledge of GenAI.

	Normal School (n=299)	Technological Institute (n=33)	University (n=61)
I have heard the term, but I am not sure what it is	19.1%	21.2%	16.4%
I am not familiar with it	4.7%	6.1%	0%
Yes, I am familiar with the concept and its tools	14%	27.3%	29.5%
Yes, I have a general idea	62.2%	45.5%	54.1%

Note. Based on the frequencies reported in the table, the association between institution type and knowledge of GenAI was statistically significant, χ^2 (6, N = 393) = 13.97, p =.030, Cramér's V =.13, indicating a small association. Authors' own work (2026).

Knowledge of GenAI (see Table 1) varied across institutional groups. Among Normal School students, 62.2% reported having a general understanding of GenAI, 19.1% had heard the term but were unsure of its meaning, 14.0% reported familiarity with the concept and its tools, and 4.7% indicated no familiarity. Among Technological Institute students, 45.5% reported having a general understanding, 27.3% were familiar with the concept and its tools, 21.2% had heard the term without clearly understanding it, and 6.1% reported no familiarity. Among University students, 54.1% reported having a general understanding, 29.5% were familiar with the concept and its tools, and 16.4% had heard the term without clearly understanding it; none reported complete unfamiliarity. The association between institution type and level of GenAI knowledge was statistically significant, although the magnitude of the association was small.

Regarding the tools used, ChatGPT was the most frequently used tool across all institutional types: 86.3% of students in Normal Schools reported using it, compared with 84.5% in Technological Institutes and 91.8% in universities. Gemini also showed notable use across contexts: 72.5% in Normal Schools, 63.6% in Technological Institutes, and 72.1% in universities. Copilot was reported by 7.02% of students in Normal Schools, 24.5% in Technological Institutes, and 21.3% in universities. Other tools, such as Claude, LuzIA, DeepSeek, Midjourney/DALL·E, Meta AI, NotebookLM, and Blackbox, were mentioned less frequently.

Table 2

Academic Frequency of GenAI Use.

Frequency of use	Normal Schools (n = 299)	Technological Institute (n = 33)	University (n = 61)
Daily	17 (5.7%)	4 (12.1%)	8 (13.1%)
Several times a week	85 (28.4%)	7 (21.2%)	21 (34.4%)
Once a week	33 (11.0%)	2 (6.1%)	5 (8.2%)
Occasionally	160 (53.5%)	18 (54.5%)	27 (44.3%)
Never	4 (1.3%)	2 (6.1%)	0 (0.0%)
Total	299 (100%)	33 (100%)	61 (100%)

Note. Percentages were calculated within each institutional group. Because six of the fifteen expected cell frequencies were below five, the association between institution type and frequency of GenAI use was evaluated using the Fisher-Freeman-Halton exact test with Monte Carlo estimation. The analysis did not identify a statistically significant association between the variables (Monte Carlo p ≈.120). Cramér's V =.13 indicated a small association. Authors' own work (2026).

Regarding academic frequency of GenAI use (see Table 2), occasional use predominated across the three institutional groups, accounting for 53.5% of Normal School students, 54.5% of Technological Institute students, and 44.3% of University students. Use several times a week was reported by 28.4%, 21.2%, and 34.4% of the respective groups. Daily use was comparatively less frequent. The Fisher-Freeman-Halton exact test did not identify a statistically significant association between institution type and frequency of GenAI use (Monte Carlo p ≈.120), while Cramér's V =.13 indicated a small association. Therefore, the observed differences among institutional groups were interpreted descriptively rather than as statistically significant institutional differences.

Students used GenAI mainly for "idea generation or inspiration", which was the most frequent activity across all institutional types: 83.9% in Normal Schools, 69.7% in Technological Institutes, and 72.1% in universities. "Concept explanation not previously understood" was reported by 60.8% at Normal Schools, 45.4% at

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Technological Institutes, and 65.6% at universities. The "creation of images, graphics, or presentations" was reported by 39.8% at Normal Schools, 21.2% at Technological Institutes, and 26.2% at universities. "Text summarization" accounted for 52.4% in universities, 36.45% in Technological Institutes, and 32.8% in Normal Schools. "Task organization or planning" was indicated by 24.6% in universities, 21.2% in Technological Institutes, and 13.8% in Normal Schools. "Drafting texts or full assignments" corresponded to 26.2% in universities, 21.2% in Technological Institutes, and 16% in Normal Schools. "Solving problems or exercises" was reported by 24.6% of university students, 24.2% of Technological Institute students, and 7.3% of Normal School students. Finally, "text translation" was reported by 24.2% in Technological Institutes, 21.3% in universities, and 4.3% in Normal Schools.

Regarding the mention of GenAI use in academic work, 39.8% of students from Normal Schools reported "never" mentioning it, a trend also observed in universities (32.8%) and Technological Institutes (39.4%). In addition, 37.5% of Normal School students said they "rarely" cite it, as did 33.3% at Technological Institutes and 32.85% at universities. The option "sometimes" was indicated by 21.1% at Normal Schools, 21.2% at Technological Institutes, and 31.1% at universities. In all three contexts, the percentage of students who "always" cite GenAI is low.

The results showed that most students had a general understanding of GenAI and used it primarily on an occasional basis. ChatGPT and Gemini were the dominant tools across all institutional types, while idea generation, concept explanation, and text summarization emerged as the most common academic applications. These findings indicate that GenAI has become a complementary resource that supports learning activities without replacing traditional academic practices.

Critical Thinking Practices Associated with GenAI Use

Table 3

Attitudes Toward GenAI Responses.

	Normal Schools (n=299)	Technological Institute (n=33)	University (n=61)
I accept and use it without further verification	7%	9.1%	4.9%
I analyze and question its coherence and logic	38.8%	45.5%	41%
I compare it with other sources (books, articles, other AIs)	19.4%	24.2%	27.9%
I modify or complement it with my own ideas	34.8%	21.2%	26.2%

Note. Displays students' attitudes toward responses generated by GenAI. Authors' own work (2026).

Regarding students' attitudes toward responses generated by GenAI (see Table 3), the most frequent response was "analyzing and questioning the coherence and logic of responses", reported by 38.8% of Normal School students, 45.5% in Technological Institutes, and 41% in Universities. "Modifying or complementing responses with their own ideas" was indicated by 34.8% in Normal Schools, 21.2% in Technological Institutes, and 26.2% in Universities. "Comparing responses with other sources" was reported by 19.4% in Normal Schools, 24.2% in Technological Institutes, and 27.9% in Universities. Finally, "accepting and using responses without further verification" was reported by 7% of Normal School students, 9.1% in Technological Institutes, and 4.9% in Universities.

With respect to reliability assessment, in all three types of institutions, the prevailing perception was that it "depends on the topic": 44.5% in Normal Schools, 51.5% in Technological Institutes, and 59% in Universities. The option of "always questioning and verifying information through external sources" was reported by 30.8% at Normal Schools, 18.2% at Technological Institutes, and 32.8% at Universities. "Using GenAI without concern for reliability, considering it only as guidance", was indicated by 18.4% in Normal Schools, 21.2% in Technological Institutes, and 8.2% in Universities. Finally, 6.4% of Normal School students, 9.1% of Technological

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Institute students, and 0% of University students reported fully trusting information generated by GenAI.

Table 4

Detection of Errors in GenAI Responses.

	Normal Schools (n=299)	Technological Institute (n=33)	University (n=61)
Never	4.7%	6.1%	3.3%
Rarely	29.1%	30.3%	18%
Yes, frequently	13.7%	12.1%	24.6%
Yes, occasionally	52.5%	51.5%	54.1%

Note. Reports students' responses regarding the detection of errors in GenAI-generated answers. Authors' own work (2026).

Table 4 shows that students detected errors, biases, or incomplete information mainly at an "occasional" level across all institutional types: 52.5% in Normal Schools, 51.5% in Technological Institutes, and 54.1% in universities. The option "rarely" was reported by 29.1% in Normal Schools, 30.3% in Technological Institutes, and 18% in universities. "Frequent" detection was reported by 13.7% of Normal Schools, 12.1% of Technological Institutes, and 24.6% of universities. Finally, 4.7% of Normal School students, 6.1% in Technological Institutes, and 3.3% in universities indicated that they had "never" detected errors or biases.

Regarding actions taken after identifying errors or potential biases, the most common response across institutions was to "correct the information using other references": 41.1% in Normal Schools, 36.4% in Technological Institutes, and 54.1% in universities. "Ignoring the response and seeking information from another source" was indicated by 27.1% of students in Normal Schools, 30.3% in Technological Institutes, and 14.8% in universities. Asking the GenAI system "to review or justify its response" was indicated by 18.7% in Normal Schools, 24.7% in Technological Institutes, and 26.2% in universities.

Concerning institutional regulations, 39.8% of students in Normal Schools reported that "no clear policy exists" on GenAI use; 35.5% noted it is "permitted under certain conditions"; 19.7% were "unsure"; and 5% stated it is "prohibited". In Technological Institutes, 42.4% reported "not knowing whether any formal regulation exists", 36.4% stated there is "no clear policy", 18.2% indicated it is "permitted under certain conditions", and 3% reported it is "prohibited". In Universities, 39.3% indicated that its use is "permitted under certain conditions", 29.5% indicated there is "no clear policy", 27.9% were "uncertain", and 3.3% reported that it is "prohibited".

The findings indicated that students generally adopted a cautious approach toward GenAI-generated information. Most participants reported analyzing the coherence of responses, comparing information with external sources, and occasionally identifying errors or biases. Corrective actions frequently included consulting alternative references or requesting additional justification from the AI system. These results suggest moderate levels of critical engagement during GenAI use.

Perceived Impact of GenAI on Learning and Critical Thinking

Table 5

Perceived Improvement in Critical Thinking.

	Normal Schools (n=299)	Technological Institute (n=33)	University (n=61)
It has not changed	21.7%	15.2%	23%
No, it has decreased	11%	6.1%	8.2%
Yes, significantly	15.1%	12.1%	24.6%
Yes, somewhat	52.2%	66.7%	44.3%

Note. Presents students' perceptions of improvement in critical thinking when using GenAI. Authors' own work (2026).

Table 5 presents students' perceptions regarding improvement in critical thinking. Across all three types of institutions, the predominant response was that GenAI has improved this ability "somewhat": 52.2% Normal Schools, 66.7% in Technological Institutes, and 44.3% in universities. The perception that it has "not changed" was reported by 21.7% in Normal Schools, 15.2% in Technological Institutes, and 23% in universities. The belief that it has improved "significantly" was reported by 15.1% at Normal Schools, 12.1% at Technological Institutes, and 24.6% at universities. Finally, 11% of students in Normal Schools, 6.1% in Technological Institutes, and 8.2% in universities indicated that this ability has "decreased".

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Regarding the impact on learning, across all three contexts, the most frequent response was that GenAI supports learning only "if used carefully": 57.9% in Normal Schools, 63.6% in Technological Institutes, and 44.3% in universities. The perception that it "facilitated understanding and saved time" was reported by 23.7% in Normal Schools, 27.3% in Technological Institutes, and 41% in universities. The perception that it "does not help and may limit independent learning" was reported by 12.7% in Normal Schools, 9.1% in Technological Institutes, and 14.8% in universities. Only students from Normal Schools expressed "uncertainty" about this matter.

Table 6

Use of GenAI Without Critical Thinking and Its Impact on Academic Development.

	Normal Schools (n=299)	Technological Institute (n=33)	University (n=61)
It depends on how it is used	45.2%	45.5%	32.8%
I don't know	1.3%	0%	1.6%
No, it is just another tool	20.1%	27.3%	19.7%
Yes, negatively	33.4%	27.3%	45.9%

Note. Presents students' perceptions regarding the use of GenAI without critical thinking and its potential impact on academic development. Authors' own work (2026).

When examining whether the use of GenAI without critical thinking may affect academic development (see Table 6), 45.2% of students in Normal Schools, 45.5% in Technological Institutes, and 32.8% in universities indicated that it "depends on how it is used". The perception that it "negatively" affects academic development was reported by 33.4% in Normal Schools, 27.3% in Technological Institutes, and 45.9% in universities. The perception that it "does not affect academic formation and is simply another tool" was noted by 20.1% in Normal Schools, 27.3% in Technological Institutes, and 19.7% in universities. A smaller proportion, 1.3% in Normal Schools and 1.6% in universities, indicated they were "unsure" of its potential effects.

Regarding orientation on GenAI use, 61.9% of students in Normal Schools reported "not having received guidance but expressed interest in receiving it", compared with 57.6% in Technological Institutes and 52.5% in universities. "Guidance sought independently" was reported by 16.4% in Normal Schools, 15.2% in Technological Institutes, and 18% in universities. "Receiving orientation in classes or workshops" was noted by 16.4% in Normal Schools, 18.2% in Technological Institutes, and 19.7% in universities. Finally, 5.4% of Normal School students, 9.1% in Technological Institutes, and 9.8% in universities indicated that they had not received orientation and did not consider it necessary.

Table 7

Future Use of GenAI.

	Normal Schools (n=299)	Technological Institute (n=33)	University (n=61)
I am not sure	8%	6.1%	3.3%
No, I prefer to avoid it	9.4%	21.2%	11.5%
Yes, much more	10.7%	12.1%	19.7%
Yes, but with clear limits	71.9%	60.6%	65.6%

Note. Indicates students' perceptions regarding future use of GenAI. Authors' own work (2026).

Finally, Table 7 shows that 71.9% of students in Normal Schools, 65.6% in Universities, and 60.6% in Technological Institutes expressed a desire to use GenAI "more in the future, but with clear limits". The intention to use it "much more frequently" was indicated by 10.7% in Normal Schools, 12.1% in Technological Institutes, and 19.7% in Universities. The preference to "avoid its use" was reported by 9.4% in Normal Schools, 21.2% in Technological Institutes, and 11.5% in Universities. A smaller proportion of students across all contexts expressed "uncertainty".

Students generally perceived GenAI as beneficial for learning when used carefully and responsibly. Most participants reported some perceived improvement in their critical-thinking abilities and expressed interest in continuing to use these tools under clear guidelines and limitations. The findings also indicated a widespread demand for training, institutional support, and ethical guidance on the use of GenAI in higher education.

The open-ended responses provided complementary descriptive evidence regarding

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students' perceptions of the benefits, risks, and responsible use of GenAI. Recurring responses concerning perceived benefits included time savings, greater efficiency in academic tasks, support for understanding complex content, idea generation, and assistance with writing and presentations. Frequently identified risks included excessive dependence on GenAI, superficial processing of information, acceptance of inaccurate content, reduced autonomy, and concerns related to plagiarism and academic integrity. Because these responses were used as complementary descriptive evidence rather than as an independent qualitative dataset, their interpretation was limited to recurrent patterns that supported contextual understanding of the quantitative findings.

Students' recommendations emphasized verifying AI-generated information using reliable academic sources, comparing generated responses with scholarly literature, examining coherence and possible biases, and avoiding uncritical acceptance of the first generated response. Participants also highlighted the need for institutional guidelines, teacher mediation, and training activities addressing responsible, ethical, and reflective use. These responses complemented the quantitative findings by indicating that students perceived the educational value of GenAI as dependent on verification, critical engagement, and appropriate pedagogical guidance.

Relationship Between GenAI Use and Critical Thinking

Spearman's rank correlation analysis showed statistically significant positive associations between frequency of GenAI use and error or bias detection (ρ =.124, p =.014), corrective or verification actions (ρ =.139, p =.006), perceived improvement in critical thinking (ρ =.256, p <.001), and perceived support for learning (ρ =.344, p <.001). The magnitude of these associations ranged from weak to moderate, indicating that statistical significance should not be interpreted as evidence of a strong relationship. No statistically significant association was observed between frequency of use and attitude toward GenAI responses (ρ = −.076, p =.134) or reliability assessment (ρ =.027, p =.597). These findings indicate association rather than causation and therefore do not demonstrate that increased GenAI use directly improves critical thinking.

Table 8

Spearman's Correlations.

Variable 1 (Use)	Variable 2	Correlation Coefficient (ρ)	Sig. (two-tailed)
Frequency of use	Detection of errors/biases	.124	.014
Frequency of use	Corrective actions/verification	.139	.006
Frequency of use	Improvement in critical thinking	.256	<.001
Frequency of use	Perceived support for learning	.344	<.001
Frequency of use	Attitude toward responses	−.076	.134
Frequency of use	Reliability assessment	.027	.597

Note. Indicates Spearman's Correlations between frequency of GenAI use and indicators of critical thinking. Authors' own work (2026).

The correlation results (see Table 8) provided empirical support for the three hypotheses examined in the study. H1 was supported because frequency of GenAI use was positively associated with perceived improvement in critical thinking (ρ =.256, p <.001). H2 was also supported, as frequency of use showed a positive association with the detection of errors, biases, or incomplete information (ρ =.124, p =.014). H3 was supported by the positive association between frequency of use and corrective or verification actions (ρ =.139, p =.006). Nevertheless, the weak-to-moderate coefficients indicate that these relationships were limited in magnitude and should not be interpreted as evidence that frequent GenAI use independently produces stronger critical-thinking skills.

Institution-specific analyses showed variation in the magnitude of selected associations. Among Normal School students (n = 299), frequency of GenAI use was positively associated with error detection (ρ =.129, p =.026) and perceived improvement in critical thinking (ρ =.204, p <.001). Among University students (n = 61), the association between frequency of use and perceived improvement in critical thinking was stronger (ρ =.398, p =.001). A similar positive association was observed among Technological Institute students (n = 33; ρ =.348, p =.047). These subgroup findings should be interpreted cautiously because of the substantial differences in group sizes, particularly

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the small Technological Institute subsample, which reduced statistical power and limited direct comparisons across institutions.

Overall, the results showed that GenAI has become a widely used academic support tool among higher education students in Zacatecas. Its use was associated with practices related to information verification, error detection, and perceived improvement in critical thinking; however, concerns regarding dependency and inaccurate information were also identified. The observed relationships suggest that the educational impact of GenAI depends largely on how students interact with these technologies and the extent to which critical and reflective practices accompany their use.

Discussion

The findings answer the research question by indicating that GenAI use among the participating higher education students was predominantly occasional and oriented toward complementary academic activities such as idea generation, concept explanation, summarization, and task support. Its relationship with critical thinking was reflected primarily in students' self-reported practices of verification, coherence assessment, error detection, and correction of potentially inaccurate information. The statistically significant associations identified were weak to moderate, suggesting that frequency of GenAI use alone does not explain students' critical engagement. Rather, the findings indicate that the educational relevance of GenAI is associated with how students evaluate, verify, and critically use generated information.

These findings are consistent with Cotton et al. (2024) and García (2023), who warn that uncritical use of GenAI may increase dependency, reduce cognitive effort, and weaken students' capacity to evaluate information independently. In this study, students recognized risks associated with errors, biases, plagiarism, and excessive reliance on automated responses, which suggests that the integration of GenAI requires more than access to digital tools. It demands explicit training in verification, source comparison, responsible prompting, and academic integrity. This result reinforces the need to understand GenAI not as a substitute for student reasoning, but as a support resource whose value depends on the critical practices activated during its use.

The moderate and complementary use identified in this study is also consistent with Baek et al. (2024), Freeman (2025), Solís et al. (2024), and Fernández et al. (2024), who report that students mainly use GenAI to save time, generate ideas, understand complex concepts, and improve academic writing. However, the results from Zacatecas suggest a more cautious pattern of adoption, since most participants indicated that GenAI supports learning only when used carefully and with clear limits. This finding is relevant for Latin American higher education contexts, where institutional policies, digital literacy, and equitable access may influence how students appropriate these tools for academic purposes.

The findings also converge with recent evidence concerning the integration of artificial intelligence into higher education. Cruz-Avalos et al. (2025) identify opportunities associated with AI use in higher education while emphasizing the importance of appropriate, ethical, and responsible integration into academic activities. The present findings extend this discussion by showing that students' favorable perceptions coexist with concerns about dependency, misinformation, and insufficient institutional guidance. This convergence suggests that access to GenAI should not be treated as equivalent to meaningful educational integration; rather, institutions need to combine technological access with digital competence, critical verification practices, academic-integrity standards, and pedagogical mediation.

Regarding critical thinking, the correlations found between frequency of GenAI use, error detection, perceived improvement in analytical capacity, and perceived support for learning suggest a positive but limited association. This result is consistent with Sergeeva et al. (2025), who emphasize that technology adoption is influenced by perceived usefulness, habit, and responsible use conditions. Nevertheless, the weak-to-moderate strength of the correlations indicates that frequent use alone is insufficient to guarantee critical thinking development. Students may interact regularly with GenAI without necessarily improving their skepticism, verification habits, or analytical depth. Therefore, the findings support the need for

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structured pedagogical interventions that transform tool use into critical learning practice.

The comparison by institutional type provides an additional contribution to the discussion. Differences among Normal Schools, Universities, and Technological Institutes suggest that GenAI adoption is shaped by academic context, institutional culture, and students' disciplinary needs. This interpretation is consistent with Morales et al. (2025), who identify differentiated profiles of perception and use in Latin American university students, influenced by educational and digital conditions. Specifically, it was observed that University students showed greater familiarity with GenAI tools and a stronger perception of improved critical thinking, while Technological Institute students exhibited more reserved attitudes toward future use. Students at the Normal Schools, for their part, showed a more homogeneous pattern of occasional use and a greater tendency to modify responses with their own ideas. Although gender was included as a sociodemographic characteristic of the sample, the present analysis did not formally test gender-based differences in GenAI use or critical-thinking indicators. Consequently, no inferential conclusions regarding gender effects are drawn from the present study. Future research may examine whether gender interacts with institutional context, digital competence, academic discipline, or previous experience with GenAI (Galindo-Domínguez et al., 2024); Downey et al., 2025).

The findings also reinforce the importance of ethical and pedagogical guidance. Cabeza-Rodríguez (2025) emphasizes that the effective integration of GenAI in higher education requires teacher mediation, clear academic rules, and training processes that promote autonomous learning. In the present study, students expressed the need for courses, workshops, and institutional guidelines to prevent dependency and encourage responsible use. This evidence supports the idea that institutional regulation should not be limited to prohibition or permission, but should include criteria for citation, transparency, verification, authorship, and the responsible use of generated content.

Several limitations should be considered when interpreting the findings. First, the use of non-probability convenience sampling and the predominance of Normal School students limited the representativeness of the sample and restricted generalization beyond the participating institutions. Second, the study relied primarily on self-reported measures, which may have been affected by social-desirability bias, recall limitations, and differences between perceived and objectively demonstrated critical-thinking performance. Third, the cross-sectional design allowed associations to be identified but did not establish temporal precedence or causal relationships. Finally, critical thinking was examined through students' reported practices and perceptions rather than through a standardized performance-based measure. Consequently, the findings should be interpreted as evidence concerning perceived critical-thinking improvement and self-reported critical practices associated with GenAI use rather than as direct evidence of measurable gains in critical-thinking ability.

Future research should incorporate longitudinal and experimental designs to evaluate whether guided GenAI use produces measurable improvements in critical thinking over time. It would also be valuable to expand the sample to include more diverse public and private higher education institutions, as well as to compare disciplinary areas and levels of digital access. Future studies should include objective measures of critical thinking, such as performance tasks, rubrics, pretest-posttest designs, or classroom-based interventions. In addition, research aligned with the Heredia Declaration should examine how transparency, equity, responsibility, and human intellectual autonomy can guide the ethical integration of GenAI in higher education.

Conclusions

This study contributes evidence showing that GenAI has become a complementary academic resource among higher education students in the participating institutions of Zacatecas. Its relevance lies not merely in the frequency with which students use these technologies, but in the critical practices that accompany their use, including verification, comparison of sources, coherence assessment, and correction of inaccurate information. The findings indicate statistically significant but weak-to-moderate associations between GenAI use

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and selected self-reported indicators of critical engagement. Accordingly, the study does not support the conclusion that GenAI independently strengthens critical thinking; instead, it suggests that its educational value is associated with reflective and responsible patterns of use.

The findings indicate that future integration of GenAI into higher education will depend substantially on the pedagogical and institutional conditions under which these tools are incorporated. Students' demand for guidance, together with concerns about misinformation, dependency, and academic integrity, highlights the need for educational strategies that combine technological competence with critical evaluation of generated content. Because the study employed a cross-sectional, non-experimental design, the identified associations cannot be interpreted causally. In addition, the reliance on self-reported measures means that perceived improvement in critical thinking should be distinguished from objectively demonstrated cognitive performance.

Future research should employ longitudinal, experimental, or quasi-experimental designs to determine whether structured GenAI-supported learning produces measurable changes in critical-thinking performance over time. Studies should incorporate validated performance-based instruments, pretest-posttest measures, more balanced probabilistic samples, and comparisons across disciplines and institutional contexts. Higher education institutions should also develop transparent policies addressing responsible GenAI use, verification of generated information, academic authorship, citation practices, and teacher-mediated learning activities. These directions may contribute to a more rigorous, ethical, and pedagogically meaningful integration of GenAI into higher education.

Declaration of Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the conduct of this study or the interpretation of its results. Furthermore, they state that they maintain no personal, academic, or financial relationships that could influence the development or findings of the research.

Funding Statement

The authors declare that this research received no funding from public, private, or commercial institutions and was conducted using their own resources, thereby ensuring the independence of the research process.

Ethics Statement

The study involved minimal-risk educational research and collected no personally identifiable information. In accordance with the applicable institutional regulations, the study was exempt from formal ethics committee review. All participants provided informed consent before completing the questionnaire.

Statement on the Use of Artificial Intelligence

The authors declare that Grok, developed by xAI, was used in its free version available in February 2026 exclusively to assist with manuscript drafting, language refinement, and proofreading. The use of this tool was limited to these editorial tasks and did not replace the authors' intellectual contributions or their responsibility for the accuracy, integrity, and scientific content of the manuscript.

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