PsiqueMag
Revista Científica Digital de Psicología
https://doi.org/10.18050/psiquemag

Universidad César Vallejo

Didactic Strategies and Development of Critical Thinking in University Students: An Analysis by Modeling Structural Equations

Estrategias didácticas y desarrollo del pensamiento crítico en estudiantes universitarios: un análisis mediante modelamiento de ecuaciones estructurales

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Fecha de recepción: 14.12.2025
Fecha de aprobación: 29.04.2026
Fecha de publicación: 20.07.2026

How to cite: Paredes-Rosales, F. (2026). Estrategias didácticas y desarrollo del pensamiento crítico en estudiantes universitarios: un análisis mediante modelamiento de ecuaciones estructurales. *Psiquemag 15* (1), 88-97.
https://doi.org/10.18050/psiquemag.v15i1.4349

Abstract

Critical thinking is a key competence in higher education; however, its development remains limited among university students. The aim of this study was to examine the relationship between active teaching strategies based on argumentative competencies and critical thinking in higher education students. A quantitative approach with a non-experimental, cross-sectional, and correlational design was employed. The sample consisted of 180 university students selected through non-probabilistic convenience sampling. Data were analyzed using exploratory factor analysis, confirmatory factor analysis, and structural equation modeling estimated with the unweighted least squares (ULS) method. The instruments showed adequate validity and reliability ($\alpha \geq .75$; AVE $\geq .50$; CR $\geq .70$). The structural model demonstrated acceptable fit (CFI = .93; RMSEA = .065) and a positive, significant association between active teaching strategies and critical thinking ($\beta = .77$, $p < .001$), explaining 60% of its variance. Findings suggest that argumentation-based, collaborative, and problem-solving teaching approaches are associated with higher levels of critical thinking. Implications for pedagogical planning and higher education are discussed.

Keywords: critical thinking; active teaching strategies; higher education; argumentative competencies; structural equation modeling.

Resumen

El desarrollo del pensamiento crítico constituye una competencia clave en la educación superior; sin embargo, persisten limitaciones en su formación en estudiantes universitarios. El objetivo de este estudio fue analizar la relación entre las estrategias didácticas activas basadas en competencias argumentativas y el pensamiento crítico en estudiantes de educación superior. Se adoptó un enfoque cuantitativo con diseño no experimental, transversal y alcance correlacional. La muestra estuvo conformada por 180 estudiantes universitarios seleccionados mediante muestreo no probabilístico por conveniencia. Los datos se analizaron mediante análisis factorial exploratorio, análisis factorial confirmatorio y modelamiento de ecuaciones estructurales utilizando el método de mínimos cuadrados no ponderados (ULS). Los instrumentos evidenciaron adecuados niveles de validez y confiabilidad ($\alpha \geq .75$; AVE $\geq .50$; CR $\geq .70$). El modelo estructural mostró un ajuste aceptable (CFI = .93; RMSEA = .065) y una asociación positiva y significativa entre las estrategias didácticas activas y el pensamiento crítico ($\beta = .77$, $p < .001$), explicando el 60% de su varianza. Los resultados sugieren que las metodologías centradas en la argumentación, el trabajo colaborativo y la resolución de problemas se asocian con mayores niveles de pensamiento crítico. Se discuten implicaciones para la planificación pedagógica y la formación universitaria.

Palabras clave: pensamiento crítico; estrategias didácticas activas; educación superior; competencias argumentativas; ecuaciones estructurales.

INTRODUCTION

Critical thinking has consolidated itself as a key cross-cutting competency in contemporary higher education, particularly in disciplines where the interpretation of complex information, reasoned argumentation, and informed decision-making constitute core pillars of academic and professional performance. In contexts characterized by an overabundance of information, misinformation, and the growing complexity of social problems, the development of higher-order cognitive skills—such as analysis, inference, evaluation, and self-regulation—is essential for the comprehensive education of students (Ennis, 1985; Facione, 1990; Halpern, 2014; Kuhn, 2019; Paul & Elder, 2008).

Several studies have demonstrated that traditional teaching models in higher education continue to privilege content transmission over the development of complex cognitive skills, thereby limiting students' ability to construct knowledge autonomously and critically (Abrami et al., 2015; Brookfield, 2017; Prince, 2004). In this regard, empirical evidence has shown that explicit instruction in critical thinking yields significant effects only when systematically integrated into the curriculum and linked to active pedagogical practices (Abrami et al., 2015; Tiruneh et al., 2018). This situation reflects a gap between the argumentative competencies required in academic and professional settings and those actually developed in the classroom, a problem also documented in international contexts (Andrews, 2015; Nussbaum, 2008).

From a pedagogical perspective, the literature has highlighted the role of active instructional strategies in fostering critical thinking, particularly those centered on argumentation, problem-based learning, and case analysis (Hmelo-Silver, 2004; Kuhn, 2019). These methodologies promote the active construction of knowledge and foster cognitive processes such as evidence evaluation, counterargument generation, and reasoned decision-making (Jonassen, 2011; Osborne, 2010). Along these lines, various studies have shown that strategies based on academic argumentation -such as structured debates, argumentative writing, and collaborative learning- contribute significantly to the development of critical thinking by encouraging discursive interaction and metacognitive reflection (Andrews, 2015; Quezada et al., 2024). Furthermore, these approaches foster intrinsic motivation, self-regulation, and academic engagement -essential elements for deep learning (Zimmerman, 2002).

Empirically, recent studies have demonstrated that integrating argumentative practices into educational environments improves not only academic performance but also students' ability to critically analyze information and participate in complex decision-making processes (Kuhn, 2019; Tiruneh et al., 2018). However, despite these advances, limitations persist in the literature regarding the structural validation of these pedagogical approaches through rigorous statistical models. In particular, studies that integrate the instructional design of teaching strategies with psychometric validation procedures -such as confirmatory factor analysis and structural equation modeling- are scarce, limiting the replicability and generalizability of findings (Hair et al., 2010; Kline, 2016; Schumacker & Lomax, 2016). This limitation highlights the need to develop pedagogical models that are not only conceptually sound but also empirically verifiable

To address this issue, the present study aims to design and validate an instructional strategy centered on argumentative competencies to enhance critical thinking in university students. To this end, a quantitative approach with an instrumental component is adopted, integrating exploratory factor analysis, confirmatory factor analysis, and structural equation modeling to evaluate the internal structure of the instruments and the relationships among the constructs. The relevance of this research lies in its contribution to the development of structurally validated pedagogical models that articulate instructional innovation with methodological rigor. In the context of Peruvian higher education, incorporating strategies based on argumentation constitutes a pertinent pathway to strengthen critical thinking and promote academic training aligned with international standards. In this sense, the study provides empirical evidence supporting the systematic integration of argumentative competencies as a core axis for developing critical thinking in the university setting.

Based on the reviewed theoretical framework and prior empirical evidence, the following research hypotheses are proposed:

H1. Active instructional strategies based on argumentative competencies are positively and significantly associated with the development of critical thinking in university students.

H2. The dimensions of active instructional strategies (collaborative work, academic debates, case studies, project-based learning, and the use of digital materials) present significant factor loadings in the measurement model.

H3. The dimensions of critical thinking (analysis, inference, evaluation, explanation, and self-regulation) configure a factor model with adequate validity and reliability indicators.

H4. The proposed structural model fits the empirical data adequately, as evidenced by goodness-of-fit indices within acceptable ranges.

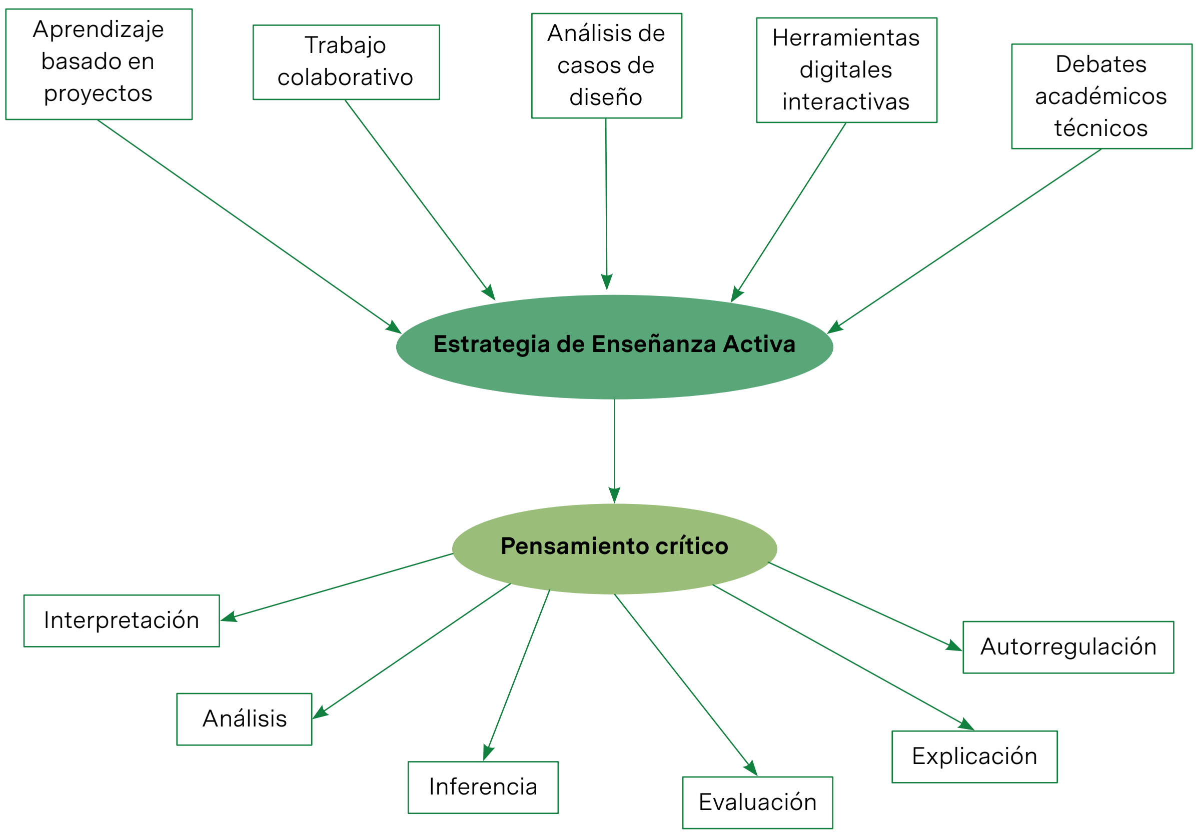
MATERIAL AND METHOD

Study Type and Design

This research was conducted using a quantitative approach, aimed at objectively measuring variables through structured instruments and statistically analyzing relationships between constructs (Hernández-Sampieri & Mendoza, 2018). The study is applied in nature, seeking to generate empirical evidence aimed at improving pedagogical practices in higher education contexts (Bisquerra, 2019). A non-experimental, cross-sectional design was adopted, as variables were not manipulated but observed in their natural context (Kerlinger & Lee, 2002). The scope of the study is correlational, analyzing associations between active instructional strategies and critical thinking while avoiding causal inferences given the nature of the design (Ato et al., 2013). Additionally, the study includes an instrumental component by evaluating the psychometric properties of the instrument used, such as construct validity and internal consistency, in accordance with social science measurement standards (Muñiz, 2018).

Figure 1

Modelo estructural de la estrategia didáctica activa orientada al desarrollo del pensamiento crítico



Participants

The sample consisted of 180 undergraduate students in their initial academic terms, selected through non-probability convenience sampling based on institutional accessibility and availability. This type of sampling is common in educational research aimed at analyzing relationships among variables in real-world settings (Etikan *et al.*, 2016).

Instruments

Two instruments were created to assess the study constructs: (a) *active instructional strategies based on argumentative competencies*, and (b) *critical thinking*, in line with established theoretical models (Facione, 1990); both instruments utilized a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). Content validity was evaluated through expert judgment for both instruments, a procedure recommended to ensure the relevance and conceptual coherence of the items (Escobar-Pérez & Cuervo-Martínez, 2008). The exploratory internal structure was examined using exploratory factor analysis (EFA), considering criteria such as factor loadings (> .40) and communalities. Internal consistency was estimated using Cronbach's alpha coefficient, with values ≥ .70 adopted as indicators of acceptable reliability (Nunnally & Bernstein, 1994). Specifically, the following psychometric data were obtained:

Active instructional strategies included five dimensions: collaborative work, academic debates, case studies, project-based learning, and the use of interactive digital materials. A confirmatory factor analysis was performed to evaluate the construct validity of the active instructional strategies model. The model showed an adequate fit to the data: χ^2/gl = 2.41; CFI = .94; TLI = .92; RMSEA = .071; SRMR = .058, indicating an acceptable factor structure (Kline, 2016). Standardized factor loadings ranged between .58 and .82, demonstrating an adequate relationship between items and their respective factors. In terms of convergent validity, average variance extracted (AVE) values ranged from .50 to .63, while composite reliability (CR) presented values between .74 and .88, exceeding recommended criteria (Hair *et al.*, 2010).

Critical thinking was operationalized based on five dimensions: analysis, inference, evaluation, explanation, and self-regulation. The measurement model for the critical thinking construct was evaluated through confirmatory factor analysis, demonstrating adequate fit: χ^2/gl = 2.76; CFI = .93; TLI = .91; RMSEA = .074; SRMR = .061. Standardized factor loadings ranged from .60 to .84, indicating adequate representation of the construct's theoretical dimensions. Convergent validity was confirmed with AVE values between .52 and .66, while composite reliability (CR) ranged from .76 to .89.

Data Analysis

Data analysis was performed using Jamovi (Version 2.3) and JASP (Version 0.18) statistical software. Descriptive and multivariate statistical techniques were applied sequentially to evaluate instrument structures and relationships among constructs. In the first stage, data suitability was examined using the Kaiser-Meyer-Olkin (KMO) index and Bartlett's test of sphericity to verify the factorability of the correlation matrix (Hair et al., 2010). Subsequently, an exploratory factor analysis (EFA) was conducted to identify the underlying structure of the constructs, considering factor loadings ≥ .40 and adequate communality values. In the second stage, internal consistency was evaluated using Cronbach's alpha coefficient (≥ .70) (Nunnally & Bernstein, 1994). Next, a confirmatory factor analysis (CFA) was conducted to evaluate construct validity. Standardized factor loadings, average variance extracted (AVE ≥ .50) and composite reliability (CR ≥ .70), were analyzed according to Fornell and Larcker's (1981) criteria. Finally, the structural model was estimated via structural equation modeling (SEM) using the unweighted least squares (ULS) method, suitable for relatively small sample sizes (Kline, 2016). Model fit was evaluated using indices such as χ^2/df, CFI, NFI, IFI, RMSEA y RMR (Browne & Cudeck, 1993; Hair et al., 2010). Structural coefficients (β) and the coefficient of determination (R^2) were used to examine the magnitude of associations among variables. Given the cross-sectional design, results are interpreted in terms of associative relationships (Ato *et al.*, 2013).

Ethical Aspects

This study was conducted in accordance with ethical principles established for research in the social and educational sciences, guaranteeing respect for the dignity, autonomy, and confidentiality of participants (American Psychological Association, 2017). Furthermore, procedures aligned with the general principles of the Declaration of Helsinki regarding research involving human beings (World Medical Association, 2013).

The research received approval from the relevant academic authority of the university institution where the study was conducted, adhering to current institutional regulations for student research. Prior to data collection, participants were clearly and comprehensibly informed about the study's objectives, academic nature, voluntary participation, and their right to withdraw at any time without academic consequences. All students provided free and explicit informed consent, in compliance with ethical standards for human beings research (American Psychological Association, 2017).

Anonymity was guaranteed through questionnaire coding and the removal of any identifiable information. Data were treated confidentially and analyzed in aggregate, ensuring exclusive use for scientific purposes and compliance with personal data protection principles in research (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2014).

RESULTS

a) Evaluation of Measurement Instruments

An exploratory factor analysis was conducted with a preliminary sample prior to the study (n = 200) to identify the underlying structure of the instruments. Sample adequacy was confirmed by the Kaiser-Meyer-Olkin index (KMO = .82), while Bartlett's test of sphericity was significant (χ^2 = 1245.36, gl = 190, $p < .001$), supporting the factorability of the data. Principal Axis Factoring was used for factor extraction, with orthogonal Varimax rotation and Kaiser normalization applied to facilitate factor structure interpretability by achieving a "simple structure" -where each variable exhibits high loadings on a single factor and low loadings on the rest.

For the ***active instructional strategies*** construct, the EFA revealed a structure with five indicators, explaining 34.33% of the total variance. Factor loadings ranged from .58 to .78, with collaborative work (.78) and interactive digital materials (.75) displaying the highest weights. For the ***critical thinking*** construct, the analysis identified five dimensions aligned with the theoretical framework: evaluation, inference, analysis, explanation, and self-regulation. Eigenvalues exceeded 1 in all cases, and the variance explained by each dimension ranged between 25% and 34%. Average factor loadings were between .69 and .78, indicating adequate representation of items on their respective factors.

Table 1
Fit and Validity Indicators for the Measurement Model (CFA)

Measurement instruments	χ^2/gl	CFI	TLI	RMSEA	SRMR	Factor loadings	AVE	CR
Active instructional strategies	2.41	.94	.92	.071	.058	.58 – .82	.50 – .63	.74 – .88
Critical thinking	2.76	.93	.91	.074	.061	.60 – .84	.52 – .66	.76 – .89

En la tabla 1 se evaluó el modelo de medición mediante análisis factorial confirmatorio (CFA) que se realizó con la muestra de estudio (n=180) con el fin de examinar la validez de constructo de las variables latentes. Para el constructo estrategias didácticas activas, el modelo presentó un ajuste adecuado: χ^2/gl = 2.41; CFI = .94; TLI = .92; RMSEA = .071; SRMR = .058. Las cargas factoriales estandarizadas oscilaron entre .58 y .82. Los valores de varianza media extraída (AVE) se situaron entre .50 y .63, mientras que la confiabilidad compuesta (CR) osciló entre .74 y .88, evidenciando adecuada validez convergente y consistencia interna. En el caso del pensamiento crítico, el modelo evidenció un ajuste aceptable: χ^2/gl = 2.76; CFI = .93; TLI = .91; RMSEA = .074; SRMR = .061. Las cargas factoriales variaron entre .60 y .84, con valores de AVE entre .52 y .66 y CR entre .76 y .89.

Internal consistency was evaluated using Cronbach's alpha coefficient. The ***active instructional strategies*** construct presented a value of $\alpha = .75$, indicating acceptable reliability. ***Critical thinking*** dimensions showed coefficients between .79 and .85, demonstrating adequate levels of internal consistency.

b) Structural Model Fit

The structural model was estimated via structural equation modeling (SEM) using the ULS method. Global fit indices demonstrated adequate correspondence between the theoretical model and observed data: $\chi^2/gl = 4.13$; CFI = .93; NFI = .91; IFI = .93; RMSEA = .065; RMR = .041. These values fall within recommended ranges in the literature, indicating an acceptable model fit. (See table 2)

Table 2

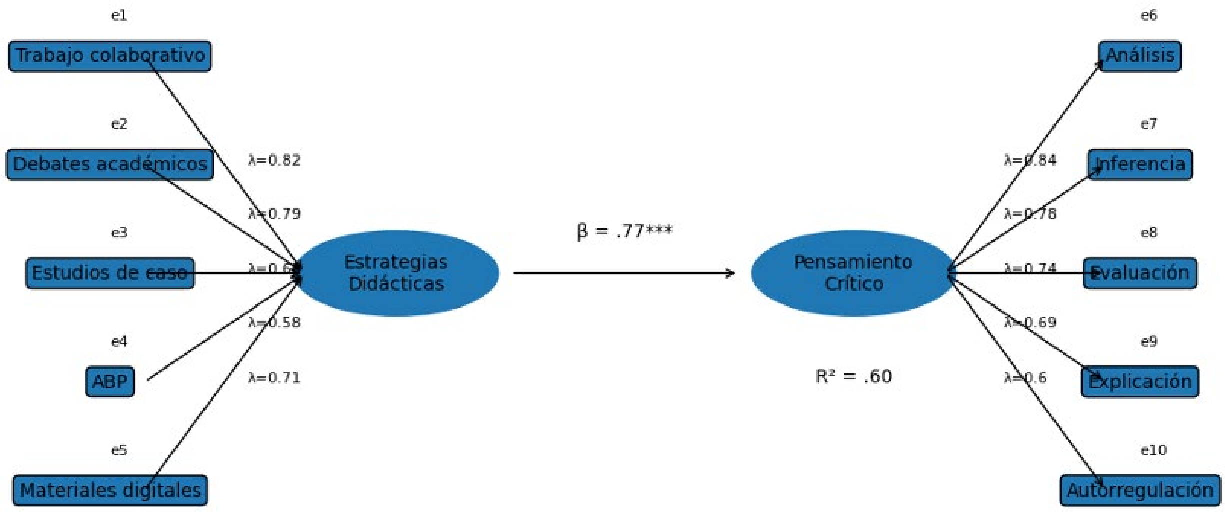
Fit Indices of the Structural Model for Active Teaching Strategies and Critical Thinking

Criterion	Statistics	Recommended value	Meet requirements	Reference
χ^2/gl	4.13	≤ 5	Sí	Hair et al. (2010)
CFI	.93	≥ 0.90	Sí	Hair et al. (2010)
RMR	.041	≤ 0.05	Sí	Hair et al. (2010)
RMSEA	.065	≤ 0.08	Sí	Browne y Cudeck (1993)
NFI	.91	≥ 0.90	Sí	Hair et al. (2010)
IFI	.93	≥ 0.90	Sí	Hair et al. (2010)

The structural model showed that active instructional strategies constitute a coherent latent construct significantly associated with the development of critical thinking. The direction and magnitude of estimated relationships suggest that methodologies such as collaborative work, academic debates, and project-based learning do not operate in isolation, but as integrated components of a pedagogical strategy aimed at strengthening higher-order cognitive skills. The graphical representation (Figure 2) of the model shows connections between the exogenous variable (active instructional strategies) and the endogenous variable (critical thinking), displaying a structural pattern consistent with the conceptual framework. This empirical validation confirms the statistical coherence of the model and supports its applicability as an instructional tool in university settings. Analysis of structural coefficients showed a positive and significant association between active instructional strategies and critical thinking ($\beta = .77$, $p < .001$). Furthermore, the model yielded a coefficient of determination of $R^2 = .60$ for critical thinking, indicating that active instructional strategies account for 60% of the construct's variance in the analyzed sample.

Figure 2

Path Diagram of the Proposed Model



Note: Exogenous variable = Teaching strategies; endogenous variable = critical thinking

DISCUSSION

The study results demonstrate a positive and significant association between active instructional strategies and critical thinking, supporting the relevance of pedagogical approaches centered on argumentation, collaborative interaction, and problem-solving in higher education. This finding is consistent with classical propositions regarding critical thinking as a complex process involving analysis, evaluation, and inference skills (Ennis, 1985; Facione, 1990), and aligns with recent empirical evidence showing that active methodologies foster the development of these competencies when systematically integrated into the curriculum (Abrami *et al.*, 2015; Tiruneh *et al.*, 2018).

In the specific context of argumentation-based instructional strategies, the findings align with prior research highlighting the role of academic debates and discursive interaction in cultivating critical thinking through counterargumentation and evidence evaluation (Andrews, 2015; Nussbaum, 2008; Osborne, 2010). On the other hand, results related to problem-based learning and case analysis are consistent with literature indicating that these methodologies promote complex reasoning by immersing students in scenarios requiring knowledge application in real-world contexts (Hmelo-Silver, 2004; Jonassen, 2011). Along these lines, collaborative work also emerges as a key component, echoing studies that show social interaction enhances metacognitive processes and learning self-regulation (Zimmerman, 2002).

From a structural perspective, the magnitude of the obtained coefficient (β = .77) suggests that active instructional strategies represent a primary factor in explaining critical thinking. However, in line with Kline (2016), these results must be interpreted as structural associations rather than causal relationships due to the cross-sectional nature of the design.

Finally, the multidimensional structure of critical thinking identified in this study supports its conceptualization as a complex construct, as widely documented in the literature (Facione, 1990; Halpern, 2014). In this regard, the study not only confirms prior findings but also contributes empirical evidence within the Latin American context, where studies integrating pedagogical innovation with rigorous structural validation remain limited.

LIMITACIONS

This study presents several limitations that should be considered when interpreting the results. First, the cross-sectional design precludes establishing causal relationships between active instructional strategies and critical thinking; therefore, findings must be interpreted in terms of structural associations (Ato et al., 2013; Kline, 2016). Second, the use of non-probability convenience sampling limits the generalizability of results to other educational contexts. Although the model demonstrated adequate validity and reliability indicators, its applicability is restricted to the institutional context analyzed. Furthermore, the reliance on self-report instruments may introduce biases associated with participants' subjective perceptions. Although satisfactory psychometric properties were obtained, incorporating complementary measures would strengthen the validity of the findings (Hair et al., 2010). Additionally, the study focused on structural validation at a single point in time, without evaluating the temporal stability of the model. Future studies could incorporate longitudinal designs to analyze the evolution of critical thinking over time (Halpern, 2014). Finally, critical thinking is a multidimensional construct influenced by various personal and contextual variables that were not examined in this study.

CONCLUSIONS

This study provides empirical evidence regarding the association between active instructional strategies and the development of critical thinking in university students. Based on exploratory factor analysis and structural equation modeling, the results demonstrate that methodologies centered on argumentation, collaborative work, and academic deliberation are positively associated with critical thinking, accounting for a substantial proportion of its variance in the analyzed sample. These findings support the importance of integrating active pedagogical approaches into university instruction, particularly during early academic terms.

Moreover, the study provides evidence for the psychometric validity of a multidimensional instrument evaluating critical thinking across its dimensions of analysis, inference, evaluation, explanation, and self-regulation, demonstrating adequate internal consistency and construct validity. In this sense, the work contributes both to the understanding of the phenomenon and to the development of methodological tools for its assessment in educational settings.

From an applied perspective, the findings offer guidance for pedagogical planning in higher education, suggesting that instructional strategies based on interaction, academic dialogue, and problem-solving can foster learning environments that promote critical thinking. However, the findings must be interpreted considering the limitations of the cross-sectional design. Consequently, future research could incorporate longitudinal or quasi-experimental designs, as well as additional variables -such as academic motivation or classroom climate- to expand understanding of the phenomenon.

Funding Sources:
This research did not receive specific funding from public, commercial, or nonprofit entities.

Conflict of interest:
The author declares that he has no conflicts of interest related to the research, authorship, and/or publication of this article.

Author's Role:
Conceptualization of the study, methodological design, and drafting of the introduction. Data collection was performed by the research team. The principal investigator was responsible for the statistical analysis and presentation of the results.

Ethical approval:
The research was conducted with the appropriate authorizations, and the confidentiality and informed consent of the participants were ensured.

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