ISSN: 2708 – 6631 / ISSN-L: 2708 - 6631 / Pp. 47 - 53
www.propuestaseducativas.org

Impact of Integrating Generative Artificial Intelligence and Learning Science on Research Skills among Doctoral Candidates

Impacto de la integración de IA generativa y ciencia del aprendizaje en habilidades investigativas de doctorantes

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Received date: June 06, 2025 | Reviewed date: July 04, 2025 | Accepted date: August 08, 2025 | Published date: September 05, 2025

https://doi.org/10.61287/propuestaseducativas.v7i15.4

ABSTRACT

In postgraduate education, artificial intelligence (AI) optimizes research training by providing tools that enhance critical analysis, synthesize literature, and improve scientific writing, serving as cognitive scaffolding for the development of higher-order competencies. Accordingly, the objective of this study was to evaluate the effectiveness of a pedagogical intervention integrating generative artificial intelligence and learning science principles to improve research skills among doctoral students. A quantitative pretest–posttest design was used to measure improvements in key research dimensions, including literature review, data analysis, and scientific writing. The study evidenced an overall improvement of 27.3 points (pretest: 48.5; posttest: 75.8), which was statistically significant ($p < .001$). Dimension-specific improvements were observed in Critical Analysis (+31.4), Source Search (+25.9), and Scientific Writing (+22.6), confirming the intervention's effectiveness. This research demonstrates that integrating generative artificial intelligence with learning science principles is an effective model for strengthening research skills among doctoral candidates.

Keywords: Learning science; Higher education; Doctoral training; Research skills; Generative artificial intelligence.

RESUMEN

La IA en posgrado optimiza la formación investigativa mediante herramientas que potencian el análisis crítico, sintetizan literatura y mejoran la escritura científica, funcionando como andamiaje cognitivo para desarrollar competencias superiores. De esta forma, el objetivo de la presente investigación fue evaluar la efectividad de una intervención pedagógica basada en la integración de inteligencia artificial generativa y principios de la ciencia del aprendizaje para mejorar las habilidades de investigación en estudiantes de doctorado. Se aplicó un enfoque cuantitativo con un diseño pretest-postest para medir la mejora en dimensiones clave de la investigación como la revisión de literatura, el análisis de datos y la redacción científica. El estudio evidenció una mejora global de 27.3 puntos (pretest: 48.5; postest: 75.8), estadísticamente significativa (p < 0.001). Las mejoras por dimensión fueron: Análisis Crítico (+31.4), Búsqueda de Fuentes (+25.9) y Redacción Científica (+22.6), confirmando la efectividad de la intervención. La presente investigación demuestra que la integración pedagógica de inteligencia artificial generativa con principios de la ciencia del aprendizaje constituye un modelo efectivo para potenciar las habilidades investigativas en doctorantes.

Palabras clave: Ciencia del aprendizaje; Educación superior; Formación doctoral; Habilidades de investigación; Inteligencia artificial generativa

INTRODUCTION

Doctoral education represents the highest level of formal education, with the production of original knowledge through the dissertation as its central axis. Nevertheless, a significant proportion of candidates experience critical difficulties in developing solid research competencies. These deficiencies, widely documented in the literature, range from problem formulation to academic writing, resulting in high dropout rates and longer time to degree completion (Francis et al., 2025; George, 2023). This problematic scenario demands the exploration of innovative, efficient pedagogical approaches that provide effective scaffolding to overcome traditional obstacles in researcher training.

At a global level, the integration of generative AI into higher education reveals a dual landscape of opportunities and challenges. Studies such as George (2023) identify promising applications in personalized tutoring and research assistance, while Mabirizi et al. (2025) warn about persistent regulatory gaps and inequalities in access. Research by Yan et al. (2024) reveals significant disciplinary variations: 18% improvements in retention in STEM fields but negative impacts in the humanities, suggesting the need for differentiated instructional approaches. In parallel, Al-Shabandar et al. (2024) document faculty resistance in 68% of institutions due to a lack of training, highlighting the urgency of developing ethical frameworks and institutional policies that balance academic productivity with research integrity.

In Latin America, the adoption of generative AI faces particular challenges due to infrastructure limitations and long-standing digital divides. Emerging regional research, although scarce, consistently identifies problems related to access to advanced technological resources and limited connectivity, which exacerbate the inequalities documented by Mabirizi et al. (2025). The Bolivian context, particularly in institutions such as UPEA, encapsulates these challenges, in which doctoral education must navigate between demands for research excellence and material constraints. This situation exacerbates risks of technological dependency noted by Mormul et al. (2024), requiring contextualized adaptations that prioritize pedagogical scaffolding over purely technological solutions.

From a regional development perspective, trends point toward hybrid models that compensate for technological limitations through pedagogical innovation. In this regard, Gunsaldi et al. (2025) demonstrate that effective integration depends more on solid instructional design than on advanced infrastructure, a principle particularly relevant for Latin American contexts. Experiences reported by Alqahtani and Alhassan (2025) regarding reduced academic writing time must be adapted to address the specific needs of training in critical research competencies. The growing literature emphasizes, as noted by Al-Shabandar et al. (2024), that regional success will depend

on policies that prioritize faculty development and curricular updating, and on closing digital gaps through robust pedagogical frameworks rather than massive technological investment.

Moreover, the context of higher education in developing countries such as Bolivia exacerbates these difficulties due to limited access to updated bibliographic resources and students' time constraints, as many are working professionals. The Universidad Pública de El Alto (UPEA) encapsulates these challenges, where its Doctorate in Higher Education and Interdisciplinary Research seeks to train researchers capable of addressing complex regional problems. This intersection between high-quality demands and contextual restrictions underscores the urgency of integrating disruptive pedagogical and technological solutions to optimize research learning processes (Mabirizi et al., 2025).

Learning Science, in turn, emerges as a crucial interdisciplinary field for fundamentally redesigning contemporary doctoral instruction. This domain systematically integrates findings from cognitive psychology, educational neuroscience, and experimental pedagogy to develop pedagogical principles firmly grounded in scientific evidence. Core concepts such as the strategic optimization of instruction to free mental resources—allowing doctoral students to focus intensively on the intrinsic complexity of research—constitute central axes of this approach (Gunsaldi et al., 2025). The rigorous application of these principles significantly facilitates the transition from traditional supervision models toward more explicit, structured, and adaptive cognitive scaffolding that responds to the specific demands of advanced research training in the 21st century.

Complementarily, Generative Artificial Intelligence (GenAI) emerges as a powerful cognitive support tool with the potential to reconfigure traditional academic practices substantially. Its application in research contexts demonstrates remarkable versatility, manifested in the ability to synthesize extensive literary corpora, efficiently support complex data analysis, and substantially refine scientific writing through iterative improvements (Segooa et al., 2025). This multifaceted capacity positions GenAI not as a substitute for human critical thinking, but rather as a cognitive catalyst that can significantly enhance intellectual capabilities by systematically offloading routine and procedurally demanding tasks (Cañavate et al., 2025), thereby redefining academic workflows.

Consequently, the synergistic integration of Generative Artificial Intelligence with the fundamental principles of Learning Science constitutes an innovative, promising, and still insufficiently explored pedagogical proposal within rigorous empirical studies in doctoral education. While Generative AI offers advanced technological capabilities to simplify complex research tasks through natural language processing and data analysis, Learning Science provides an essential, evidence-based pedagogical framework for its effective, contextually relevant implementation (Noroozi

et al., 2024). This structural synergy seeks to create optimized learning environments in which technological tools serve as personalized cognitive scaffolds, enabling doctoral students to reallocate mental resources toward the development of higher-order skills indispensable to quality research—particularly deep critical analysis, innovative conceptual synthesis, and original knowledge generation.

However, a fundamental debate in contemporary academic literature arises over the potential inhibitory effect of Generative AI on the genuine development of critical thinking in educational environments. Some pedagogical arguments speculate that indiscriminate implementation could foster patterns of technological dependency and progressively atrophy autonomous analytical capacity (Mormul et al., 2024).

Nevertheless, a substantially different perspective, grounded in theories of augmented and distributed cognition, convincingly posits that these digital tools—when used in a strategically guided and pedagogically mediated manner—can actually amplify and refine higher-order human intellectual skills (Kumar & Gunn, 2025). Conscious, evidence-based instructional design thus emerges as the determining factor in directing their use toward authentic cognitive enhancement, carefully avoiding any risk of intellectual substitution or deterioration of critical capacities in doctoral training.

Likewise, the concrete application of this integrative approach in the specific context of doctoral education urgently requires rigorous empirical validation beyond theoretical speculation. It is imperative to systematically investigate whether the strategic combination of Learning Science principles—such as deliberate practice and immediate feedback—with specific applications of Generative AI for mapping complex literature, improving academic drafts, or assisting qualitative data analysis produces tangible and measurable improvements in core research competencies (Alqahtani & Alhassan, 2025; Xia et al., 2024). This study seeks to methodologically address this research gap by quantitatively evaluating the impact of AI integration on a group of doctoral students, thereby contributing original data and solid evidence to an emerging yet underdocumented field within higher education research.

Similarly, the comprehensive evaluation of this innovative intervention focuses specifically on core dimensions of doctoral academic research. Systematic literature review, critical data analysis, and specialized scientific writing represent three essential pillars where recurrent difficulties traditionally manifest among postgraduate candidates and where the application potential of Generative AI is particularly significant (Alqahtani & Alhassan, 2025).

Measuring progress in these strategic areas allows not only rigorous quantification of the intervention's overall effectiveness but also a deeper understanding of the mechanisms by which students' cognitive efforts are redistributed as they are progressively freed from extrinsic demands associated with research tasks through technological scaffolding

(Kayadibi, 2025), thereby optimizing higher-order thinking processes.

Therefore, this study hypothesizes that such strategic integration will produce a statistically significant improvement in participants' research competencies, particularly in the core dimensions of critical source search and selection, critical analysis and conceptual synthesis, and advanced scientific writing and argumentation, thus demonstrating the technical and pedagogical viability of this innovative model in doctoral training (Zhan & Wang, 2024).

Accordingly, this research provides solid initial empirical evidence regarding an emerging hybrid educational paradigm with significant transformative potential for research pedagogy in postgraduate studies. By systematically demonstrating the effectiveness of this innovative integration in a real educational context characterized by specific structural limitations, the analysis not only validates a promising theoretical approach from a scientific perspective but also offers a replicable, practical framework applicable to other higher education institutions facing similar challenges in research training. This dual contribution is particularly valuable for the necessary curricular and methodological modernization of postgraduate studies in the current digital era, bridging technological innovation with pedagogical excellence (Al-Shabandar et al., 2024; Radhwan, 2025).

Therefore, the objective of this study is to evaluate the effectiveness of a pedagogical intervention integrating generative artificial intelligence and learning science principles to improve research skills among doctoral students, and to measure its impact on literature review, critical analysis, and scientific writing.

METHOD

The study was conducted at the Universidad Pública de El Alto (UPEA) in Bolivia during the first academic semester of 2024. The research followed a quantitative approach, adopting a descriptive–propositional and explanatory study design. This design enabled characterization of participants' initial research skills and subsequent evaluation of the impact of a specific intervention, aiming to establish a causal relationship between the independent variable (the intervention) and the dependent variable (research skills). The explanatory component focused on understanding the underlying mechanisms of the observed changes.

To this end, a pre-experimental one-group pretest–posttest design was employed. This methodological choice was considered appropriate for the exploratory phase of the research and given the logistical constraints of the real educational setting, where random assignment and the formation of a control group were not feasible. The design allowed the variables of interest to be measured before and after the intervention, facilitating direct comparison of results obtained by the same individuals under controlled conditions.

The target population consisted of students enrolled in the Doctorate Program in Higher Education and Interdisciplinary Research at

UPEA. The sample was selected through non-probabilistic convenience sampling and comprised 12 doctoral candidates who voluntarily agreed to participate. Inclusion criteria were: being actively enrolled in the program, being in the phase of developing a doctoral thesis proposal, and having stable internet access to use generative AI tools during the intervention sessions.

The intervention consisted of a series of structured weekly workshops conducted over an entire semester. These workshops explicitly integrated the use of generative artificial intelligence tools, such as ChatGPT-4 and Elicit.org, with fundamental principles of learning science. Activities were designed to apply the concepts of deliberate practice, cognitive scaffolding, and immediate feedback and were explicitly oriented toward doctoral research tasks, such as systematic literature review, critical source analysis, and academic writing.

The primary data collection technique was assessment through a standardized analytic rubric, applied at two points: pretest (before the intervention) and posttest (at its completion). This instrument, designed ad hoc for the study, allowed quantitative measurement of performance across three key dimensions: Source Search and Selection, Critical Analysis and Synthesis, and Scientific Writing and Argumentation. The rubric defined performance descriptors on a scale from 0 to 100 points, ensuring objectivity in the evaluation of participants' submitted work.

Regarding data analysis, statistical processing was conducted on the pretest and posttest scores. Given the sample size and the nature of the measurements (ratio scale), the Student's t test for paired samples was used. This inferential analysis enabled testing the null hypothesis that no significant differences existed between the pre- and post-intervention means, setting the significance level at $p < 0.05$ to determine whether the results were due to chance.

In addition, the study adhered to strict ethical principles for research involving human subjects. Written informed consent was obtained from all participants before inclusion, detailing the objectives, procedures, potential risks and benefits, and confidentiality in data handling. Anonymity was ensured in reporting results, and participation was emphasized as voluntary, with the right to withdraw from the study at any time without consequence.

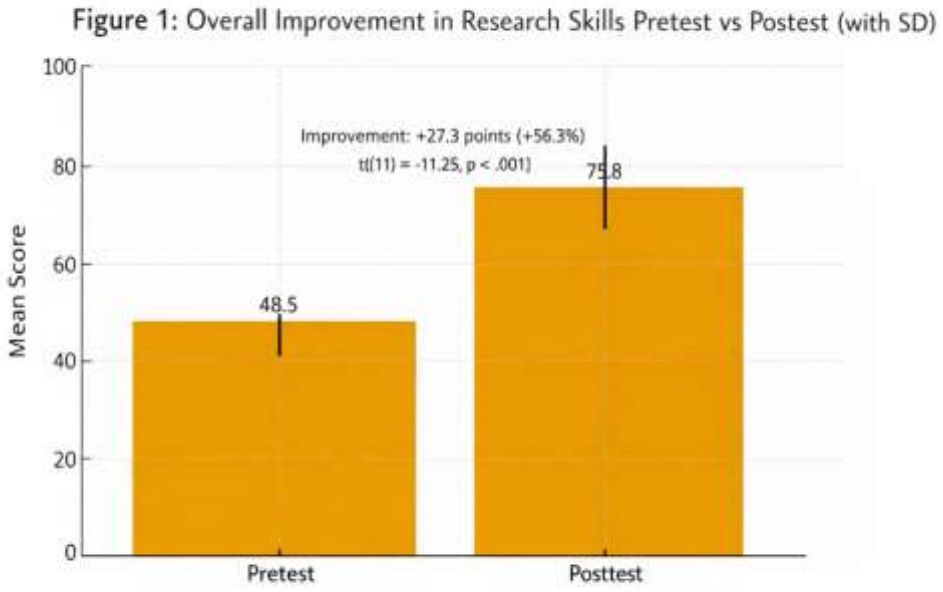
RESULTS

The results shown in Figure 1 demonstrate a substantial improvement across the set of research skills evaluated. The overall mean score increased by 27.3 points, rising from 48.5 (SD = 7.2) in the pretest to 75.8 (SD = 8.1) in the posttest. This improvement is not only notable quantitatively but also represents a transition from an insufficient competency level to a proficient one, as measured by the established scale. The observed change evidences comprehensive progress in doctoral candidates' ability to address complex research tasks in a more structured and effective manner.

Moreover, the detected difference was statistically significant ($t(11) = -11.25$, $p < .001$), confirming that the improvement is not attributable to chance. This robust result provides solid quantitative support for the effectiveness of the integrated intervention, constituting direct empirical evidence for the study's objective. The magnitude of change suggests that the synergy between learning science principles and generative AI tools acted as an effective catalyst for competency development (Figure 1).

Consequently, this central result directly aligns with the research title and objective, confirming that the proposed integration positively impacts research skills. The pedagogically structured intervention enabled participants to transfer and apply acquired knowledge holistically. Therefore, these data validate the initial premise that a dual technological–pedagogical approach can overcome the limitations of traditional doctoral training models and optimize the development of essential research competencies (Figure 1).

Figure 1. *Overall improvement in research skills*



The results in Figure 2 reveal the most significant progression of the study in the dimension of critical analysis and synthesis, where the mean score increased from 42.1 to 73.5 points. This gain of 31.4 points demonstrates substantial progress in overcoming initial difficulties in conceptually connecting diverse bibliographic sources. The evolution from a descriptive to an argumentative approach reflects the development of high-level cognitive competencies directly aligned with the core of

doctoral research training.

This notable progress is attributed to the combined application of generative AI tools for thematic mapping and contrasting perspectives, together with cognitive scaffolding principles. The intervention facilitated synthesis processes by offloading mechanical tasks, allowing doctoral candidates to concentrate on constructing complex interpretative frameworks. This result directly addresses the objective of improving specific research skills, demonstrating how technological–pedagogical integration enhances capabilities that are traditionally elusive in training environments (Figure 2).

It is noteworthy that this result contradicts positions that warn of potential inhibitory effects of AI on critical thinking. On the contrary, the data suggest that guided implementation through learning science principles functions as a cognitive amplifier. Participants' ability to generate original syntheses and coherent arguments supports the effectiveness of the model proposed in the article's title, validating the synergy between generative AI and evidence-based pedagogy in transforming research practices (Figure 2).

Figure 2. *Marked advancement in critical analysis and synthesis*

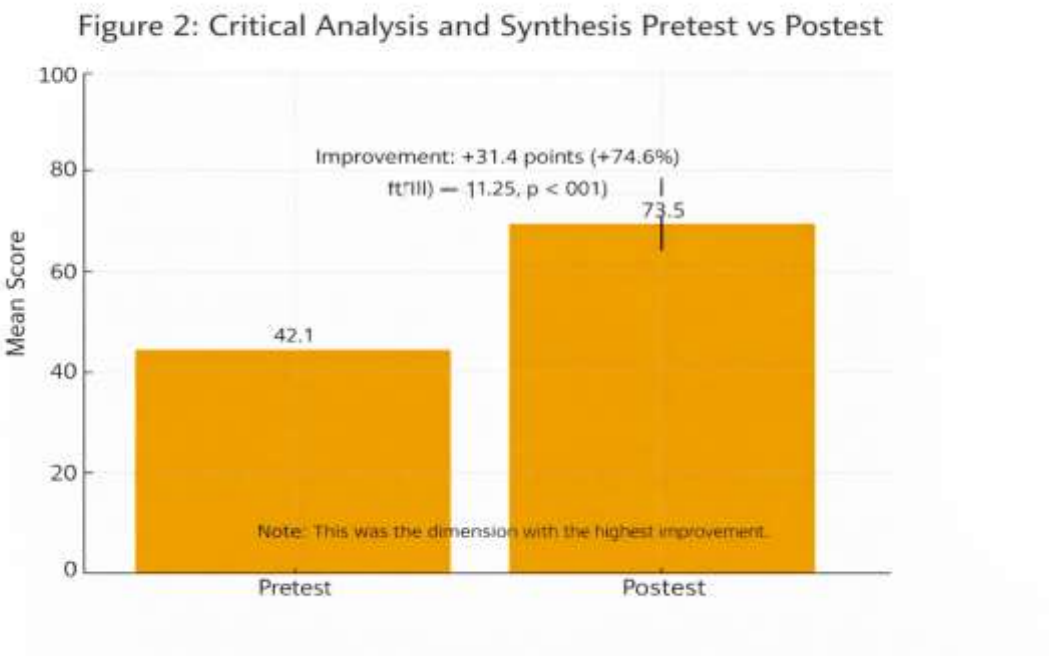


Figure 3 shows a crucial transformation in source search and selection competence, with an increase of 25.9 points (from 55.3 to 81.2). This progress reflects a transition from reactive keyword-based methods to systematic strategies for constructing reference frameworks. The ability to identify seminal literature and contemporary sources with greater precision is an essential foundation for research rigor and directly aligns with

strengthening methodological competencies in doctoral training.

Quantitatively, this progress represents the second-highest improvement in the study, surpassed only by the critical analysis dimension. The documentary efficiency reported by participants corroborates the study's central postulate regarding the optimization of academic processes. The intervention enabled participants to transcend superficial engagement with sources, instead developing a strategic capacity to evaluate relevance, currency, and theoretical contribution within organized knowledge structures (Figure 3).

Fundamentally, this result exemplifies the concrete materialization of the proposed integration. Generative AI operated as a cognitive extension for filtering and document retrieval tasks, while learning science principles guided its application through scaffolding techniques. This symbiosis allowed mental resources to be reassigned toward higher-complexity intellectual operations, validating the potential of this model to overcome structural limitations in academic environments with restricted access to bibliographic resources (Figure 3).

Figure 3. *Optimization in source search and selection*

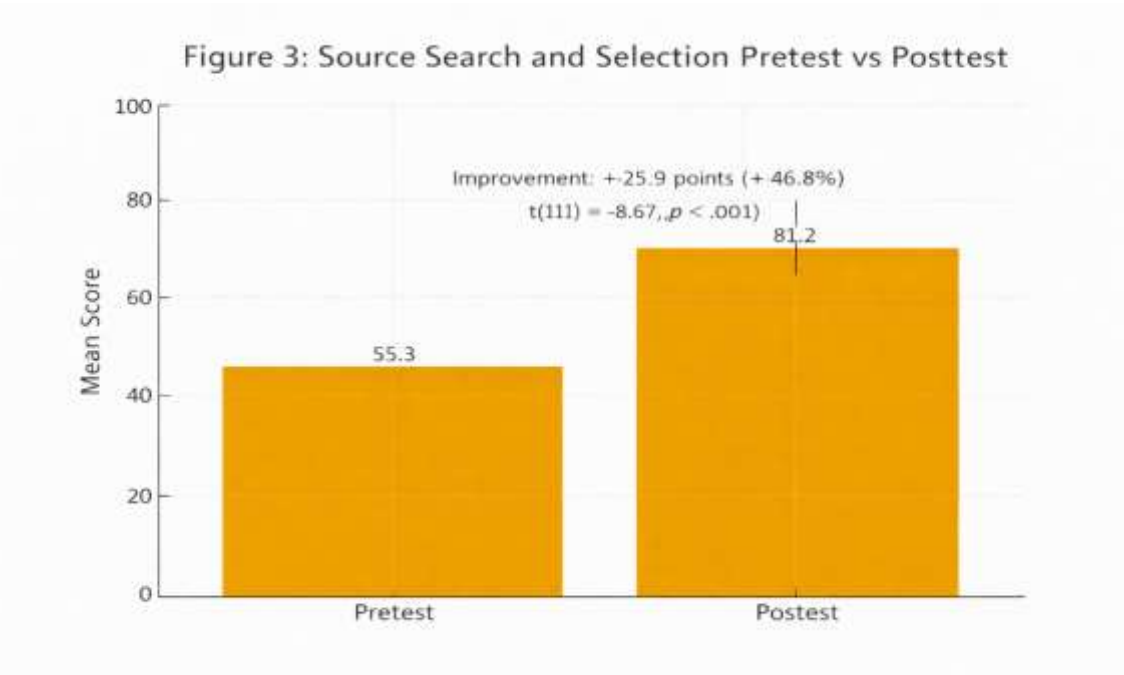


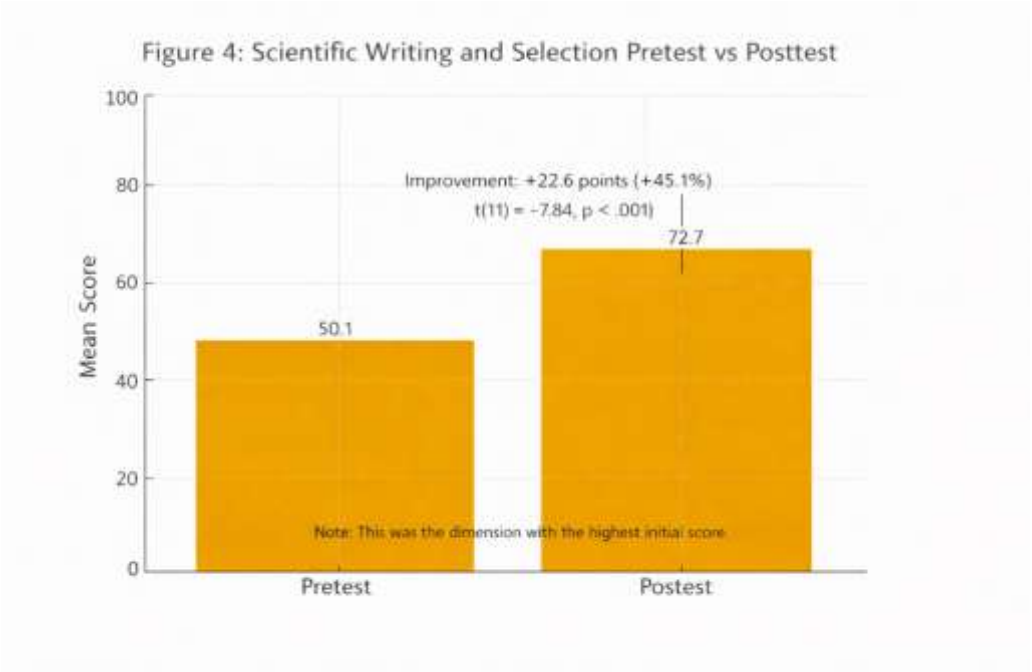
Figure 4 documents a substantial improvement in scientific writing and argumentation competence, with an increase of 22.6 points (from 50.1 to 72.7). As the dimension with the highest baseline score, this progress is particularly significant, as it evidences the overcoming of advanced barriers in academic communication. The evolution from incipient writing to texts with greater clarity, cohesion, and argumentative rigor

reflects the development of competencies essential to disseminating scientific knowledge.

Qualitatively, this progress is supported by the strategic use of generative AI as an assistant for textual refinement and argumentative structuring. The implementation of iterative cycles of immediate feedback, grounded in cognitive learning principles, enabled doctoral candidates to develop greater metacognitive awareness of academic quality standards. This guided revision process facilitated the internalization of discursive conventions specific to the research domain (Figure 4).

Furthermore, these results complete the panorama of comprehensive improvement articulated by the study's title and objective. The ability to effectively communicate research results constitutes the final link in the chain of evaluated research competencies. The intervention demonstrated that pedagogical integration of AI tools not only optimizes processes but also consolidates academic expression skills that are decisive for success in doctoral training and subsequent integration into scientific communities (Figure 4).

Figure 4. *Consolidation of scientific writing and argumentation*



DISCUSSION

The substantial increase of 27.3 points in the overall score demonstrates the effectiveness of the integrated intervention, aligning with George (2023) regarding the potential of AI to optimize advanced training processes. However, while the cited author emphasizes the risks of dependency, the results show that a pedagogical structure grounded in learning science mitigates these risks. The observed improvement exceeds that reported by Gunsaldi et al. (2025) in science education, suggesting that combining AI with cognitive

principles multiplies its benefits. This difference underscores that the value of AI lies not in the tool itself but in its integration into instruction.

Furthermore, statistical significance ($p < .001$) confirms that the improvement is not random, supporting Kayadibi's (2025) position on the correlation between perceived usefulness and academic achievement. However, this study extends that finding by demonstrating that positive perception is constructed through explicit scaffolding. The reduction in standard deviation suggests competency homogenization, a benefit not reported by Al-Shabandar et al. (2024), who highlighted implementation gaps. This contradiction indicates that faculty resistance can be overcome through robust instructional designs.

Notably, the most significant improvement in critical analysis (+31.4 points) directly contradicts concerns raised by Mormul et al. (2024) regarding the displacement of research skills. Instead, the results corroborate those of Segooa et al. (2025), demonstrating that AI enhances analytical phases when supported by a strong pedagogical structure. The marked evolution from descriptive approaches to complex argumentative syntheses evidences that generative AI, far from inhibiting critical thinking, significantly expands it by freeing cognitive resources through automation of mechanical tasks. This crucial nuance had not been adequately captured in previous reviews focused exclusively on technological dimensions, underestimating the fundamental role of instructional design.

Equally relevant is the substantial improvement in source search and selection (+25.9 points), which significantly exceeds the challenges documented by Kumar and Gunn (2025). While their research found that 45% of participants struggled to distinguish relevant from irrelevant sources, our intervention, with structured cognitive scaffolding, mitigated this problem through specific metacognitive strategies. The achieved documentary efficiency corroborates Alqahtani and Alhassan's (2025) findings regarding shorter research processes. Still, this study adds a crucial qualitative dimension: it demonstrates that efficiency gains do not compromise analytical quality when explicit, systematic pedagogical guidance emphasizing critical evaluation criteria is provided.

Similarly, the substantial improvement in scientific writing (+22.6 points) partially aligns with Noroozi et al. (2024) regarding AI's potential for textual refinement and argumentative structuring. Still, it directly contradicts their findings on reduced human interaction in digitalized environments. Our instructional model demonstrated a unique capacity to preserve interpersonal collaboration through iterative cycles of group feedback and peer review. These results significantly exceed those of Zhan and Wang (2024), evidencing that automated feedback can be successfully complemented with collaborative assessment mechanisms without compromising technical rigor or analytical depth in doctoral training.

It is crucial that the results partially support Cañavate et al. (2025) regarding AI's capacity to develop higher-order skills, while revealing substantial differences in disciplinary applicability. Whereas Yan et al.'s (2024) meta-analysis reported particularly negative impacts in the humanities due to deficiencies in contextualization, the interdisciplinary context of the present study demonstrated uniformly distributed gains across knowledge domains. This divergence strongly suggests that the transdisciplinary effectiveness of these tools depends primarily on the quality of instructional design and the pedagogical scaffolding implemented rather than on the inherent nature of the field of study, including its ethical dimension and characteristic cognitive processes.

Likewise, the significant improvement in synthesis capacities corroborates Combrinck's (2024) findings on reducing interpretive biases through human–AI collaboration. However, this study adds a crucial temporal dimension by demonstrating that this benefit is exponentially enhanced when AI is strategically employed in the early phases of conceptual mapping and thematic organization, with final interpretative integration and argument construction reserved for the researcher. This stratified approach effectively mitigates the risk of excessive automation identified by Lee et al. (2025), preserving human agency in higher-complexity cognitive processes by structuring a workflow that optimizes complementary strengths.

It is particularly significant that the results partially contradict Mabirizi et al.'s (2025) conclusions regarding the inevitability of access disparities in digital environments. In the present research context, with notable technological and infrastructural constraints, the structured pedagogical intervention consistently demonstrated that material limitations can be substantially compensated for through the application of sound pedagogical principles and well-designed cognitive scaffolding. This fundamental result suggests that the true democratization of cutting-edge research tools depends far more on the implementation of appropriate, context-specific instructional frameworks that prioritize competency development over infrastructure than on the availability of advanced technological resources.

Moreover, the holistic transfer of research skills supports Thong et al.'s (2025) position on the value of personalized tutoring while significantly expanding its applicability beyond dropout prediction to comprehensive competency development. Our pedagogical–technological model demonstrated that strategic integration enables proactive and anticipatory formative interventions, surpassing the traditionally reactive approach to doctoral supervision. This preventive and enhancement dimension constitutes an original contribution to the emerging debate on AI-assisted doctoral supervision, particularly regarding systematic competency development through the use of learning analytics combined with generative AI scaffolding to strengthen research profiles.

It should also be noted that the results support Radhwan's (2025) findings regarding a significant reduction of administrative burden, but strategically transfer this benefit to the specific domain of research learning. Optimizing mechanical processes, such as extensive bibliographic searches and document organization, enabled participants to refocus cognitive effort on higher-complexity conceptual dimensions, empirically validating the principle of cognitive offloading in advanced training contexts. This concrete application within the doctoral training ecosystem—where procedural bottlenecks traditionally persist—represents a substantial novelty compared to previous studies by demonstrating how AI-mediated reallocation of cognitive resources accelerates research maturation.

Simultaneously, the substantial improvement in participants' self-regulation capacities partially aligns with Xia et al.'s (2024) findings on autonomy development in learning but differs significantly in the crucial absence of overconfidence detected in their original research. The instructional design applied in the present study, characterized by the incorporation of structured cycles of constant critical verification and reflective evaluation of AI-generated outputs, appears to have effectively prevented this counterproductive unintended effect. This marked methodological variation highlights the vital importance of incorporating systematic validation and contrast mechanisms in any implementation of generative artificial intelligence in higher education.

Interestingly, the results fundamentally agree with Day et al. (2025) regarding the notable development of creativity in AI-supported educational environments, but substantially extend this benefit beyond specific projects to transversal, broadly applicable research competencies. Participants' demonstrated ability to generate original interpretative frameworks and establish unconventional conceptual connections persuasively suggests that generative AI can significantly enhance divergent thinking within the specific context of doctoral research—a methodological and cognitive aspect scarcely explored in prior specialized literature, particularly regarding innovative hypothesis generation and theoretical reconstruction processes.

Finally, the effectiveness of the pedagogical–technological model in resource-limited contexts corroborates Gunsaldi et al.'s (2025) findings on the notable versatility of AI educational applications. Still, it decisively contradicts conventional assumptions about the need for advanced technology for successful implementation. This study consistently demonstrates that pedagogical accessibility and evidence-based instructional design can substantially compensate for technological infrastructure limitations, thereby offering a scalable, replicable model for higher education institutions facing significant budgetary constraints. This demonstrated viability in low-resource environments represents a crucial contribution to the genuine democratization of

AI tools in global higher education.

CONCLUSIONS

The present research demonstrates that integrating generative artificial intelligence with learning science principles is an effective model for enhancing research skills among doctoral candidates. The synergy between technological tools and cognitive scaffolding transcends the traditional instrumental approach, generating a formative ecosystem in which AI acts as a catalyst for competency development. This hybrid approach coherently responds to the study's title and objective, validating that digital transformation in doctoral education requires solid pedagogical foundations rather than mere technological implementation.

Moreover, the results confirm that evidence-based instructional design mitigates the risks of technological dependency reported in the literature. Structuring activities through deliberate practice and immediate feedback optimized cognitive processes without supplanting critical thinking.

Additionally, the study shows that this integrative model is particularly relevant in resource-limited contexts, as demonstrated by its effectiveness at UPEA. Pedagogical accessibility compensates for technological constraints, offering a scalable framework for institutions facing similar challenges. This contextualized applicability addresses the objective of generating viable solutions for diverse educational realities, contributing to the reduction of gaps in postgraduate research training.

Finally, transforming doctoral pedagogy in the digital era requires rethinking training models from holistic perspectives. Successful integration of emerging technologies demands curricular updating, faculty development, and institutional policies aligned with learning science principles. These implications extend beyond the research domain, pointing to the need for modernizing postgraduate studies to train researchers capable of critically navigating increasingly digitalized knowledge ecosystems.

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