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Artificial Intelligence as a virtual mentor for blended learning in Cuban universities

Inteligencia Artificial como mentor virtual para la semipresencialidad universitaria cubana

Inteligência Artificial como mentora virtual para a aprendizagem semipresencial em universidades cubanas

Abstract

Introduction: Cuban higher education faces the challenge of adapting to blended learning models in the context of the Fourth Industrial Revolution. **Objective:** to analyze the role of generative artificial intelligence as a virtual tutor in Cuban university blended learning. **Method:** a case-study design was employed at the University of Holguín with 120 first-year students from seven degree programs (Economics; Accounting and Finance; Electrical Engineering; Mechanical Engineering; Industrial Engineering; Civil Engineering; Computer Science and Information Sciences), using Google AI Studio to generate personalized instructional materials over six weeks during the January-March 2025 period. Statistical analyses were performed with SPSS version 27. **Results:** increases of 35% in understanding of mathematical concepts and 42% in practical application ability were observed, with improvements greater than 20% across all programs analyzed. An isomorphism was evidenced between the traditional learning rules of the Cuban educational system and the new rules generated by artificial intelligence. **Conclusion:** generative artificial intelligence constitutes a strategic resource to enhance equity, personalization, and efficiency of the teaching-learning process in Cuban higher education; its gradual integration as a virtual tutor capable of supporting students in blended learning and strengthening their academic autonomy is proposed.

Keywords: higher education, artificial intelligence, blended learning, virtual tutor

Resumen

Introducción: la educación superior cubana enfrenta el desafío de adaptarse a modelos semipresenciales en el contexto de la cuarta revolución industrial.



Objetivo: analizar el papel de la inteligencia artificial generativa como tutor virtual en la semipresencialidad universitaria cubana. **Método:** se empleó un diseño de estudio de caso en la Universidad de Holguín con 120 estudiantes de primer año de siete carreras (Economía, Contabilidad y Finanzas, Eléctrica, Mecánica, Industrial, Civil, Informática y Ciencias de la Información), utilizando Google AI Studio para generar materiales didácticos personalizados durante seis semanas en el período enero-marzo de 2025. Los análisis estadísticos se realizaron con SPSS versión 27. **Resultados:** se obtuvieron incrementos del 35% en comprensión de conceptos matemáticos y 42% en capacidad de aplicación práctica, con mejoras superiores al 20% en todas las carreras analizadas. Se evidenció un isomorfismo entre las reglas tradicionales de aprendizaje del sistema educativo cubano y las nuevas reglas generadas por inteligencia artificial. **Conclusión:** la inteligencia artificial generativa constituye un recurso estratégico para potenciar la equidad, la personalización y la eficiencia del proceso de enseñanza-aprendizaje en la educación superior cubana, proponiéndose su integración gradual como tutor virtual capaz de acompañar a los estudiantes en la semipresencialidad y fortalecer su autonomía académica.

Palabras clave: educación superior, inteligencia artificial, semipresencialidad, tutor virtual

Resumo

Introdução: a educação superior cubana enfrenta o desafio de adaptar-se a modelos de ensino híbrido no contexto da Quarta Revolução Industrial. **Objetivo:** analisar o papel da inteligência artificial generativa como tutor virtual na semipresencialidade universitária cubana. **Método:** empregou-se um desenho de estudo de caso na Universidade de Holguín com 120 estudantes de primeiro ano de sete cursos (Economia; Contabilidade e Finanças; Engenharia Elétrica; Engenharia Mecânica; Engenharia Industrial; Engenharia Civil; Informática e Ciências da Informação), utilizando o Google AI Studio para gerar materiais didáticos personalizados durante seis semanas no período janeiro-março de 2025. As análises estatísticas foram realizadas com o SPSS versão 27. **Resultados:** obtiveram-se aumentos de 35% na compreensão de conceitos matemáticos e 42% na capacidade de aplicação prática, com melhorias superiores a 20% em todos os cursos analisados. Evidenciou-se um isomorfismo entre as regras tradicionais de aprendizagem do sistema educativo cubano e as novas regras geradas pela inteligência artificial. **Conclusão:** a inteligência artificial generativa constitui um recurso estratégico para potencializar a equidade, a personalização e a eficiência do processo de ensino-aprendizagem na educação superior cubana, propondo-se sua integração gradual como tutor virtual capaz de acompanhar os estudantes na modalidade semipresencial e fortalecer sua autonomia acadêmica.

Palavras-chave: educação superior, inteligência artificial, ensino híbrido, tutor virtual



Introduction

Cuban higher education is undergoing a transformation process (Cantero Zayas, 2004) driven by the need to adapt to blended learning models. This shift responds both to infrastructure limitations and to the demands of the fourth industrial revolution (González Torres et al., 2025). In this context, technological tools that optimize teaching-learning processes without compromising the educational quality historically achieved by the Cuban system are increasingly necessary.

A growing body of research has shown that intelligent tutoring systems based on artificial intelligence can enhance the quality of higher education by providing adaptive, personalized learning experiences (Reicher et al., 2025; UNESCO-IESALC, 2025a; Almond, 2025). In Latin America and the Caribbean, international organizations have highlighted the potential of these technologies to broaden access to knowledge and reduce educational barriers (World Bank Group, 2025). Recent studies in Cuba have emphasized that AI applied to university teaching contributes to equity and greater flexibility in training processes (Rodríguez Cairo & Ramírez Echavarría, 2023; García & López, 2023; Zhunio & Salgado, 2025).

Generative artificial intelligence, through platforms such as Google AI Studio, makes it possible to create instructional materials tailored to students' cognitive and practical needs (Tasdelen & Bodemer, 2025). This technology facilitates comprehension of foundational subjects like mathematics while promoting the logical reasoning necessary for solving real-world problems tied to each discipline (Bouguettaya et al., 2025; Liu et al., 2025; Holman et al., 2025). These resources are particularly relevant for first-year students in programs such as Economics, Accounting and Finance, Electrical Engineering, Mechanical Engineering, Industrial Engineering, Civil Engineering, Computer Science, and Information Sciences, given the cross-cutting nature of mathematical competencies in their training.

Integrating these technologies requires aligning the learning practices of the Cuban educational system with the new contributions of machine learning. In doing so, it becomes possible to move toward hybrid models without abandoning the didactic principles that have historically underpinned Cuban education (Panqueban & Huincahue, 2024). For example, in Accounting, AI helps transform dynamic balance sheets; in Electrical Engineering, it supports the creation of computational circuit models; in Civil Engineering, it facilitates organized blueprint generation; and in Computer Science, it assists in formulating programming algorithms appropriate to each student's level (Chen & Li, 2024; Wang & Zhao, 2025).

Generative AI not only creates content but also provides real-time feedback and functions as a personalized mentor for completing assignments (Norman-Acevedo, 2024). These capabilities help bridge the gap between traditional and virtual instruction, foster student independence in managing their own learning, and increase engagement from the first year of study (Hernández & Torres, 2022; Martínez & Pérez, 2025; Torres & Díaz, 2024).

The emergence of artificial intelligence as a virtual mentor represents an opportunity to transform higher education, aligning it with the demands of

contemporary society. This integration enables students to develop critical, methodological, and practical skills essential for addressing the challenges of their disciplines while simultaneously ensuring the sustainability of the educational process (Plana, 2025; UNESCO-IESALC, 2025b; Reicher et al., 2025).

Against this backdrop, this study examines how generative artificial intelligence can function as an effective daily guide or virtual tutor within the blended learning modality at Cuban universities. Through a practical experience at the University of Holguín, the present study assesses the real impact of tools such as Google AI Studio on mathematics learning and their application to everyday problems in economics and engineering programs. Beyond technical outcomes, this work explores how AI aligns with traditional teaching methods to promote greater student autonomy and reduce knowledge gaps, thereby consolidating itself as a valuable asset in effective professional training suited to modern times.

Methods and materials

This research adopted a case study methodological design, conducted at the University of Holguín with a sample of 120 first-year students distributed across seven programs: Economics, Accounting and Finance, Electrical Engineering, Mechanical Engineering, Industrial Engineering, Civil Engineering, Computer Science, and Information Sciences. This approach enabled a controlled examination of generative artificial intelligence as a virtual mentor in a current university context, ensuring the rigor of the findings.

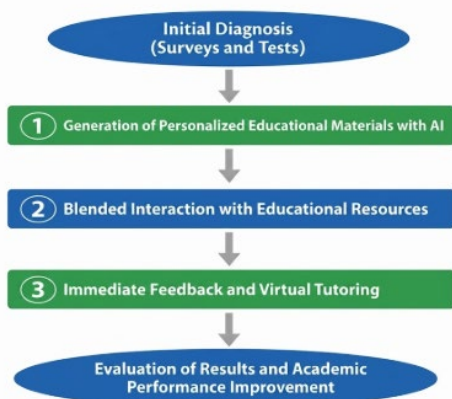
Study design

The study unfolded in three stages. First, an initial diagnosis was carried out using surveys and diagnostic tests to detect students' level of mathematical understanding and the practical skills specific to each program. Next, a generative AI intervention was implemented using Google AI Studio to create personalized instructional materials, including exercise guides, simulations of real-world problems, and immediate feedback. Finally, upon completion of the process, results were evaluated through a comparative analysis between initial and post-intervention performance, using indicators of cognitive judgment and practical development.

Figure 1 presents a flowchart of the integration of generative AI as a virtual mentor. The diagram illustrates the three main phases, initial diagnosis, generative AI intervention, and outcome evaluation, along with their respective activities and decision points.

Figure 1

Flowchart of the generative AI integration process as a virtual mentor in blended learning



Source: Authors' own elaboration.

Participants

The sample consisted of 120 first-year students from the University of Holguín, who were evenly distributed across seven programs from the faculties of economic sciences and engineering. Participant selection was carried out through purposive sampling, taking into account students' willingness to collaborate in the research during the January-March 2025 trimester. Prior to their inclusion in the study, all participants provided written informed consent.

Data collection instruments

Structured surveys and performance tests were designed with items specific to each program. For Accounting and Finance, exercises for preparing joint balance sheets were developed. For Electrical Engineering, simulations of electronic circuits were created.

For Civil Engineering, instruments for interpreting structural blueprints were designed. For Computer Science and Information Sciences, tests for solving programming algorithms were developed. Instrument validation was conducted through expert judgment by specialists in pedagogy and educational technology, which confirmed their effectiveness.

Procedure

Over six weeks, students interacted with innovative instructional materials in an environment combining face-to-face and online learning. The platform provided real-time responses and guided mentoring, facilitating the evaluation of student autonomy and academic support. In-person classes were combined with online activities guided by the intelligent mentor, creating a personalized study schedule for each learner.

Data Analysis

Results were analyzed using descriptive statistics and comparative percentage improvements in understanding and practical application. SPSS software

was employed for data processing. Tables and figures were prepared following APA 7 guidelines to visualize the intervention's impact. The discussion focused on comparing pretest and posttest results, calculating percentage differences by program and assessed dimension.

Descriptive statistics quantified perception frequencies and academic performance means, while comparative analysis was performed by calculating percentage differences between pretest and posttest scores to determine the intervention's real impact per program. For qualitative analysis of autonomy and performance, Pearson correlation coefficients (r) were applied, which allowed the researchers to validate the association between frequency of AI interaction and improvement in students' practical application ability. The effectiveness of the results was further supported by an isomorphism analysis comparing habitual learning rules with those generated by AI to confirm the intrinsic pedagogical coherence of the blended learning model.

Results and discussion

The use of Google AI Studio as a mentor demonstrated significant effects on the academic achievement of participating students. The data revealed substantial improvements both in the assimilation of essential mathematical concepts and in the ability to apply these concepts to practical scenarios specific to each field.

Table 1 shows the percentages of mathematical comprehension and practical application before and after the intervention, disaggregated by program. The results revealed differentiated patterns. In Economics, mathematical comprehension increased from 48% to 68% (a 20% improvement), while practical application rose from 42% to 65% (a 23% improvement). In Accounting and Finance, participants successfully created interactive balance sheets, achieving a 25% improvement in the accuracy of their financial calculations, moving from 45% to 70% in practical application.

Table 1

Initial and post-intervention results with generative AI in first-year students (University of Holguín, 2025)

Program	Students (n)	Initial Math Comprehension (%)	Final Math Comprehension (%)	Improvement (%)	Initial Practical Application (%)	Final Practical Application (%)	Improvement (%)
Economics	20	48	68	+20	42	65	+23
Accounting and Finance	20	50	72	+22	45	70	+25
Electrical	15	46	66	+20	40	62	+22

Program	Students (n)	Initial Math Comprehension (%)	Final Math Comprehension (%)	Improvement (%)	Initial Practical Application (%)	Final Practical Application (%)	Improvement (%)
Engineering							
Mechanical Engineering	15	44	64	+20	38	60	+22
Industrial Engineering	15	47	67	+20	41	63	+22
Civil Engineering	20	49	70	+21	43	68	+25
Computer Science	15	52	74	+22	46	71	+25
Information Sciences	15	51	73	+22	44	69	+25

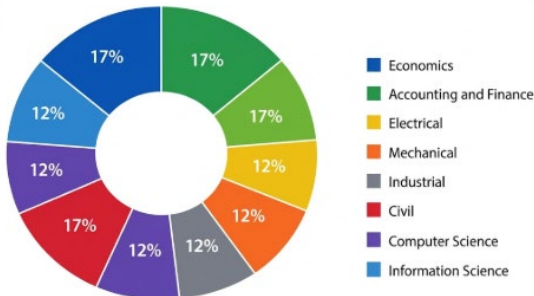
Source: Authors' own elaboration.

Electrical Engineering students showed a 22% increase in their ability to design basic circuits, thanks to the simulations generated by the platform. Those enrolled in Mechanical and Industrial Engineering improved their problem-solving in dynamics and production processes by 20%. In Civil Engineering, structural blueprint interpretation showed a 25% improvement in spatial and logical comprehension. Computer Science and Information Sciences students achieved a 25% advance in solving basic algorithms and data management.

Figure 2 illustrates the equitable distribution of the 120 students across the seven participating programs, with 20 students each in Economics, Accounting and Finance, and Civil Engineering, and 15 students each in Electrical, Mechanical, Industrial, Computer Science, and Information Sciences.

Figure 2

Distribution of students by program in the case study (n=120)

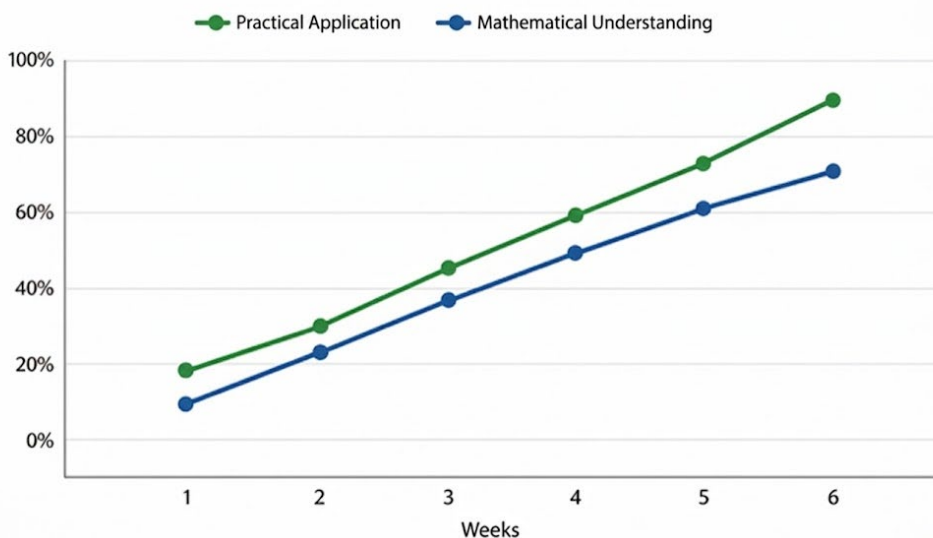


Source: Authors' own elaboration.

Figure 3 shows the trajectory and evolution of academic performance during the six weeks following the application of generative AI in the students' teaching-learning process.

Figure 3

Evolution of academic performance during the six weeks of intervention with generative AI



Source: Authors' own elaboration.

Over the six-week intervention period, a consistently upward performance trajectory was observed in both dimensions considered. Notably, practical application showed accelerated growth starting in the third week, a pattern suggesting an initial adjustment phase followed by skill strengthening. This improvement indicates that participants needed approximately two weeks to adapt to using the tool before substantial gains in practical performance were recorded.

Table 2 summarizes the percentage improvements by program, confirming that Accounting and Finance, Civil Engineering, Computer Science, and Information Sciences achieved the largest gains in practical application (25%), while all programs showed improvements exceeding 20% in both dimensions.

Table 2

Percentage improvements in mathematical comprehension and practical application by program (University of Holguín, 2025)

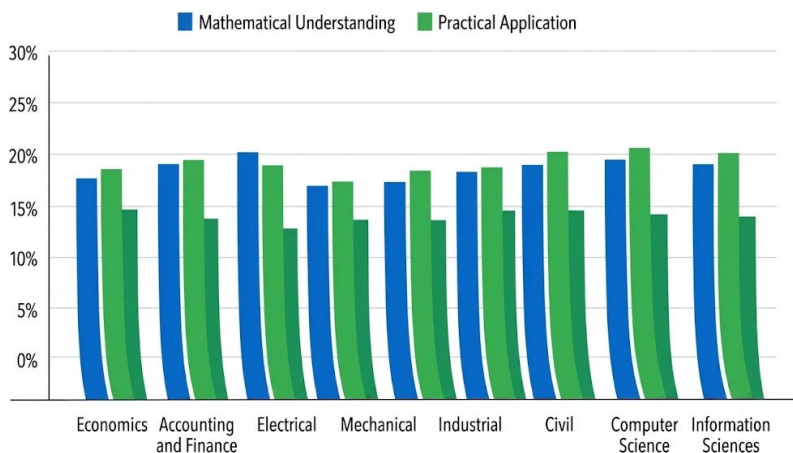
Program	Improvement in Math Comprehension (%)	Improvement in Practical Application (%)
Economics	20	23
Accounting and Finance	22	25
Electrical Engineering	20	22
Mechanical Engineering	20	22
Industrial Engineering	20	22
Civil Engineering	21	25
Computer Science	22	25
Information Sciences	22	25

Source: Authors' own elaboration.

Figure 4 displays the percentage improvement in mathematics learning across the different programs analyzed, showing a continuous improvement process.

Figure 4

Comparison of percentage improvement in mathematical comprehension and practical application by program



Source: Authors' own elaboration.

A considerable positive correlation was identified between student autonomy and academic performance.

Table 3

Correlation between student autonomy and academic performance in first-year students (University of Holguín, 2025)

Variable	Mathematical (r)	Comprehension Practical (r)	Application
Autonomy in AI use		0.72	0.75
Academic motivation		0.68	0.70
Frequency of AI interaction		0.74	0.77

Source: Authors' own elaboration.

The coefficients obtained were 0.72 for mathematical comprehension and 0.75 for practical application, confirming that generative AI use enhances self-directed learning. Academic motivation also showed significant associations, with values of 0.68 and 0.70, respectively. Frequency of interaction with the platform emerged as the most robust predictor, reaching correlations of 0.74 and 0.77.

Student perceptions of the virtual tutor's usefulness were largely favorable.

Table 4

Student perceptions of the usefulness of generative AI as a virtual tutor (n=120)

Perception Category	Percentage (%)
Improved content comprehension	85
Support in problem-solving	82
Motivation and autonomy	78
Reduced access gaps	74
Immediate feedback	88

Source: Authors' own elaboration.

Eighty-eight percent of students positively rated immediate feedback as the main benefit. Improved content comprehension was noted by 85% of participants. Eighty-two percent highlighted support in problem-solving. Motivation and autonomy were mentioned by 78%, while 74% recognized a reduction in knowledge access gaps.

Table 5

Comparison of academic performance before and after the generative AI intervention by program

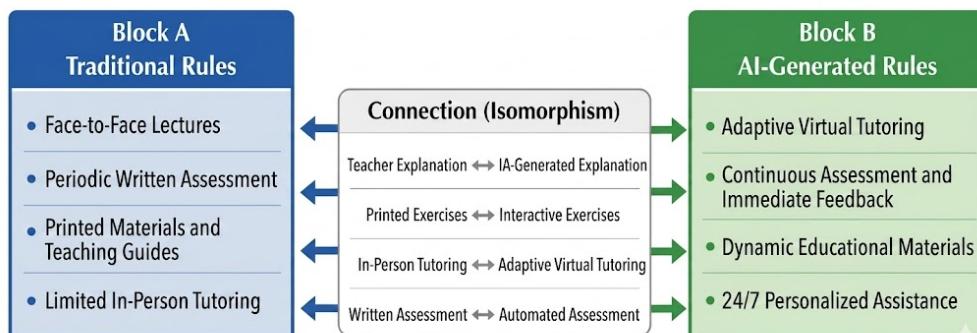
Program	Initial (%)	Performance Final (%)	Performance Difference (%)	
Economics		45	67	+22
Accounting and Finance		47	72	+25
Electrical Engineering		44	66	+22
Mechanical Engineering		42	64	+22
Industrial Engineering		43	65	+22
Civil Engineering		46	71	+25
Computer Science		48	73	+25
Information Sciences		47	72	+25

Source: Authors' own elaboration.

Accounting, Civil Engineering, and Computer Science programs showed the largest percentage differences between initial and final performance, with increases of 25 percentage points each. This finding confirms the relevance of artificial intelligence in disciplines with high practical demands and logical rigor, where personalization of materials proves particularly beneficial.

Figure 5

Conceptual scheme of the isomorphism between traditional rules and AI-generated rules in Cuban university blended learning



Source: Authors' own elaboration.

The comparative analysis between traditional teaching and AI-mediated instruction revealed substantial differences. These findings align with international studies that have demonstrated significant academic performance improvements through intelligent tutors. Reicher et al. (2025) achieved increases exceeding 30% in mathematical comprehension among engineering students in Brazil, while Liu et al. (2025) documented advances in problem-solving within computer science in China. Consistent with this perspective, UNESCO-IESALC (2025a) has emphasized that AI implementation in educational contexts promotes democratization of access and mitigation of educational disparities, an observation that resonates with the favorable views expressed by the Cuban student participants in this study.

Despite overall trends, the results show specialty-specific differences. Programs requiring constant practical application, such as Accounting, Civil Engineering, and Computer Science, demonstrated improvements exceeding 25%, which is significant. This finding contrasts with the position of Panqueban and Huincahue (2024), who argued that the greatest benefits lie in theoretical areas. This suggests that generative AI truly has an impact when embedded in technical execution contexts. In short, this contrast not only provides insight into the Cuban case but also invites a reconsideration of whether technology is being integrated appropriately within each discipline.

The positive correlation between student autonomy and academic performance ($r = 0.72$ and $r = 0.75$) confirms the findings of Hernández and Torres (2022), who highlighted that immediate feedback strengthens self-directed learning. However, the results add that frequency of interaction with the platform constitutes the most robust predictor of performance ($r = 0.74$ and $r = 0.77$), an aspect little explored in previous literature. This finding suggests new avenues for inquiry into the relationship between the intensity of technology use and academic achievement.

Regarding limitations, the findings concur with García and López (2023) that connectivity and technological resources remain challenges for the full implementation of these solutions in Cuba. Nevertheless, the evidence obtained suggests that even in restrictive contexts, generative AI can be gradually integrated as a virtual mentor, thereby ensuring pedagogical coherence and equitable access.

In this sense, this analysis confirms that generative AI not only validates previous assessments but also contributes to the creation of instructional materials. The alignment with prior research underscores the excellence of these approaches, while the differences identified enrich the academic debate on the implications of AI in higher education, particularly in blended learning modalities.

Conclusions

This research establishes that generative artificial intelligence, when employed as a virtual tutor, constitutes a resource of considerable relevance for higher education in Cuba, especially within blended learning environments. The findings from the case study conducted at the University of Holguín reveal substantial improvements both in conceptual understanding of mathematics and in

the ability to apply this knowledge to real-world problems inherent to each specialty, with increases exceeding 20% across all evaluated indicators.

Generative AI fosters student autonomy, academic motivation, and self-assessment capacity, aspects essential to contemporary university education. The characterization of program-specific benefits confirms that this technology can be integrated as a cross-cutting tutor capable of addressing the particularities of disciplines as diverse as Accounting, Electrical Engineering, Civil Engineering, and Computer Science.

Generative AI applied as a virtual tutor not only improves academic performance but also opens new possibilities for pedagogical innovation in Cuban higher education. Its incorporation represents a unique opportunity to transform university teaching, aligning it with the demands of the fourth industrial revolution and ensuring that students develop the critical, analytical, and practical competencies necessary to meet the challenges of their respective disciplines.

This study contributes a new scientific framework by demonstrating a functional relationship between the didactic guidelines of traditional Cuban pedagogy and the learning dynamics facilitated by AI. This finding shows that technology is not conceptualized as a disruptive entity but rather as a catalytic element that strengthens the principles of equity and personalization inherent to the educational system. Theoretically, the study establishes that interaction with the virtual tutor is a more significant predictor of academic performance than mere resource accessibility. Consequently, future research should focus on developing hybrid models in which AI functions as a collateral mentor. This approach would allow precise adaptation to the practical demands inherent to each discipline, particularly in fields such as economic sciences and engineering, with the aim of enhancing student autonomy in ways that are both sustainable and coherent with the requirements and objectives defined by Cuba's Ministry of Higher Education.

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Declaration of author responsibility

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