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ORIGINAL

AI-Based Digital Academic Monitors: Innovation for Enhancing Teaching in Higher Education

Monitores Académicos Digitales Basados en IA: Innovación para la Mejora de la Enseñanza en Educación Superior

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ABSTRACT

Higher education faces challenges such as overcrowded classrooms and diverse learning styles, which have driven the development of digital academic monitors based on artificial intelligence (AI). These systems aim to personalize teaching, optimize instructors' time, and strengthen students' executive functions. The objective of this research was to analyze the impact of AI-based academic monitors in higher education, focusing on their ability to improve educational quality and develop cognitive skills. A systematic bibliometric analysis (2018–2023) was conducted using VOSviewer, evaluating 60 publications across three dimensions: learning personalization, teaching optimization, and executive function development. The study identified exponential growth in research since 2021, with prominent contributions in fields such as computer science and psychology. The monitors proved effective in adapting content (e.g., platforms like ALEKS), automating administrative tasks (e.g., Moodle chatbots), and enhancing metacognitive skills (self-regulation and planning). However, ethical and privacy challenges remain. AI monitors represent a transformative innovation, but their success depends on balancing technology with human oversight, ensuring inclusivity, and training educators in their strategic use.

Keywords: Educational Artificial Intelligence; Learning Personalization; Teaching Efficiency; Executive Functions; Higher Education.

RESUMEN

De aprendizaje, lo que ha impulsado el desarrollo de monitores académicos digitales basados en inteligencia artificial (IA). Estos sistemas buscan personalizar la enseñanza, optimizar el tiempo docente y fortalecer funciones ejecutivas en los estudiantes. El objetivo de esta investigación fue analizar el impacto de los monitores académicos basados en IA en la educación superior, centrándose en su capacidad para mejorar la calidad educativa y desarrollar habilidades cognitivas. Se realizó un análisis bibliométrico sistemático (2018-2023) utilizando VOSviewer, con 60 publicaciones evaluadas en tres dimensiones: personalización del aprendizaje, optimización docente y fortalecimiento de funciones ejecutivas. Se identificó un crecimiento exponencial de investigaciones desde 2021, destacando áreas como ciencias de la computación y psicología. Los monitores demostraron eficacia en adaptar contenidos (ej. plataformas como ALEKS), automatizar tareas administrativas (chatbots en Moodle) y mejorar habilidades metacognitivas (autorregulación y planificación).

Sin embargo, persisten desafíos éticos y de privacidad. Los monitores de IA representan una innovación transformadora, pero su éxito depende de equilibrar tecnología con supervisión humana, garantizar inclusión y formar docentes en su uso estratégico.

Palabras clave: Inteligencia Artificial Educativa; Personalización del Aprendizaje; Eficiencia Docente; Funciones Ejecutivas; Educación Superior.

INTRODUCTION

Higher education faces challenges marked by the massification of classrooms, the diversification of learning styles, and the growing demand for flexible and personalized training models.[1,2] In this context, artificial intelligence (AI) emerges as a strategic ally, allowing the development of innovative tools capable of transforming educational processes.[3,4] These include digital academic monitors, systems based on adaptive algorithms that dynamically accompany the teaching-learning process.[5,6] These resources seek to optimize the management of teaching and learning.

These include digital academic monitors and systems based on adaptive algorithms that dynamically accompany teaching-learning.[5,6] These resources seek to optimize teaching management, as they can offer resources personalized to students' individual needs, thanks to real-time data analysis.[7,8]

However, it should be noted that beyond their operational efficiency, the real potential of these monitors lies in their ability to strengthen cognitive and metacognitive skills essential in professional training, as Yang et al.[9] point out. Unlike traditional tools, AI systems allow for immediate feedback, continuous adaptation of content, and the development of self-regulation skills, critical aspects in increasingly complex academic environments.[10,11]

Therefore, the purpose of this research is to analyze the strategic role of these monitors, focusing on their impact on raising educational quality and, especially, on their contribution to the development of executive functions and critical thinking. This research also intends to reflect on their responsible integration into the current educational ecosystem.

METHOD

This study employs a systematic bibliometric analysis to examine the scientific production of artificial intelligence-based digital academic monitors and their impact on university teaching. The methodology is organized along key dimensions, ensuring a comprehensive literature evaluation.[12,13]

The information search formula used was: ('digital academic monitor*' OR 'AI tutor*' OR 'intelligent tutoring system*' OR 'AI teaching assistant*' OR 'virtual learning companion*' OR 'educational chatbot*') AND ('higher education' OR 'university teach*' OR 'tertiary education' OR 'college instruction' OR 'academic learning') AND ('personalized* learn*' OR 'adaptive learn*' OR 'customize* education' OR 'individual* instruction' OR 'differentiate* teach*' OR 'teacher time management' OR 'faculty workload reduce*' OR 'automated grading' OR 'teaching efficiency' OR 'executive function*' OR 'cognitive skill*' OR "self-regulation OR 'metacognitive*' OR 'learning strategy*")

Time dimension

Scientific publications were included between 2018 and 2023, a critical period in the development of educational artificial intelligence. This timeframe allows us to identify recent advances in digital academic monitors and emerging trends in their application in higher education.

Thematic Dimension

The studies were classified into three main thematic strands:

- Personalisation of Learning: research on AI systems that adapt content, teaching rhythms, and pedagogical strategies according to individual student needs.
- Optimisation of Teaching Time: Analysis of digital tools that automate administrative tasks, formative assessment, and feedback, freeing time for activities of higher educational value.
- Role in Strengthening Executive Functions: Studies exploring how these monitors improve key cognitive skills in students, such as planning, self-regulation, and metacognition, through intelligent reminders and personalized monitoring.

Bibliometric tools

VOSviewer was used to visualize co-citation maps and thematic clusters. In addition, text mining was applied

to identify key terms such as adaptive learning, 'teacher automation,' and ' executive functions in education,' revealing connections between research areas.

This methodology allowed for a rigorous mapping of existing knowledge, highlighting how AI-based academic monitors are transforming higher education. The results reflect the current state of the field as well as point to future lines of research in personalization, teaching efficiency, and cognitive development.[14]

RESULTS

Temporal Dimension

The analysis of the scientific production of AI-based digital academic monitors in higher education reveals a significant evolution between 2018 and 2023, with 93 publications recorded (figure 1). The annual distribution shows exponential growth, particularly from 2021 onwards, which coincides with the acceleration in adopting AI technologies in education following the COVID-19 pandemic.

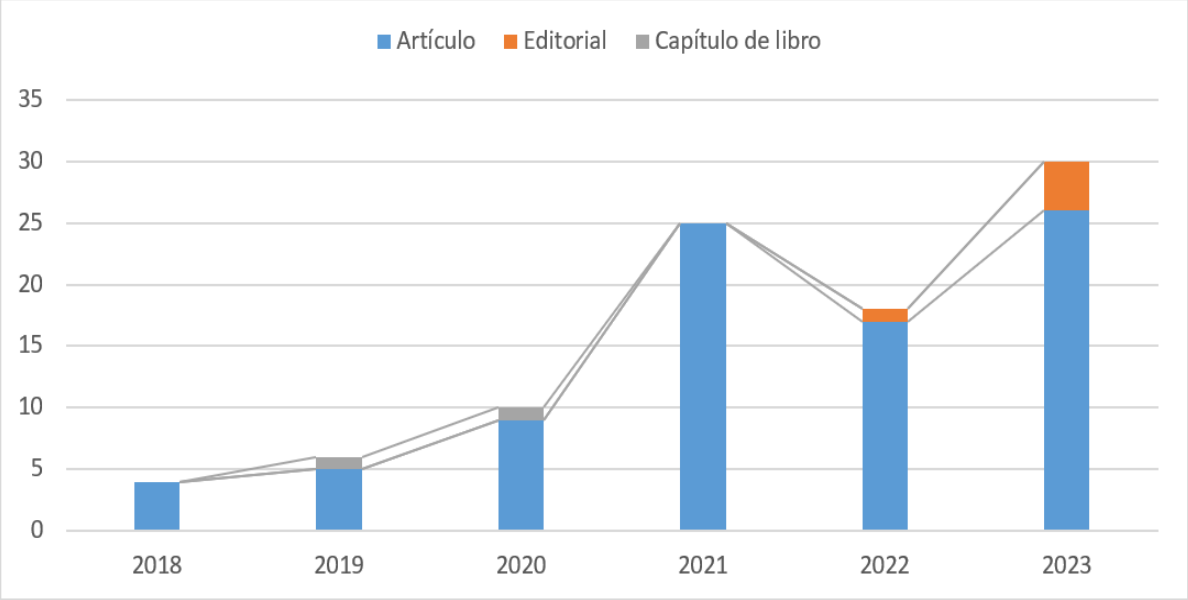

Figure 1. Temporal distribution of publications

In the first years of the period analyzed (2018-2020), the output was modest, with four articles in 2018, 6 publications in 2019 (5 articles and one book chapter), and 10 in 2020 (9 articles and one book chapter). This initial phase reflects a nascent interest in the topic, with exploratory research focusing on the potential of digital assistants for university teaching. However, from 2021 onwards, a turning point is observed, with a noticeable jump to 25 scientific articles. This could be associated with increased demand for remote and hybrid education digital solutions.

The growth continued in 2022, with 18 publications (17 articles and one editorial), consolidating the topic as an emerging line of research. However, 2023 stands out as the year with the highest productivity, with 30 records (26 articles and four editorials), suggesting a maturing field and a growing interest on the part of specialized journals in education and technology. It is worth noting that although scientific articles dominate the production (86 out of 93 publications), the appearance of editorials in 2022 and 2023 indicates a greater theoretical and informative discussion in the academic field. On the other hand, book chapters only appeared in 2019 and 2020, reflecting an initial trend towards longer formats that later led to periodicals.

Thematic dimension

The number of scientific publications by area (figure 2) highlights computer science as the dominant area, with 64 publications reflecting the central role of technological developments in this educational innovation. This is closely followed by psychology (49 publications), demonstrating the importance of understanding cognitive and behavioral processes in the interaction between learners and intelligent systems. This duality between technology and human behavior underlines that the effectiveness of these monitors depends not only on their algorithmic capability but also on their adaptation to the pedagogical and psychological needs of the users.

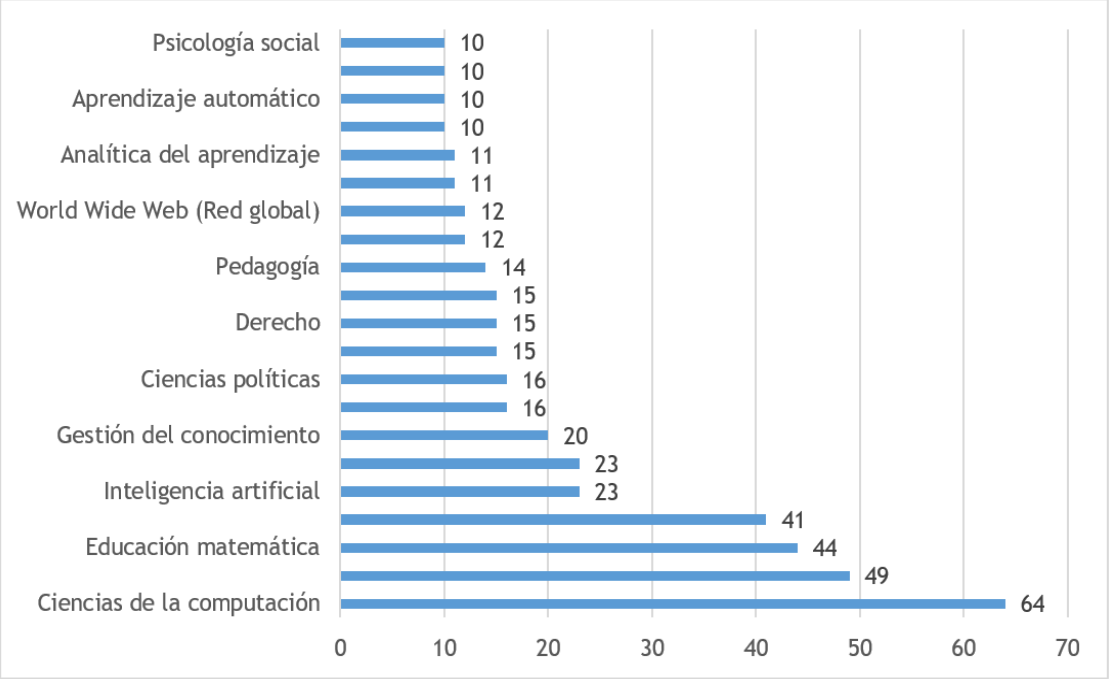

Figure 2. Prominent areas of study in the subject area

Mathematics education and educational technology are in third place, with 44 and 41 publications, respectively. This suggests a strong link between AI and the optimization of teaching methodologies in specific disciplines and the integration of digital tools in training environments. Likewise, fields such as artificial intelligence (23) and engineering (23) confirm that the technical basis of these systems is a priority. At the same time, knowledge management (20) emerges as a key area for structuring the information these monitors process and generate.

The presence of disciplines such as political science (16), law (15), and engineering ethics (15) is striking, reflecting the debates around governance, data privacy, and regulatory frameworks in the application of AI in education. Sociology (15) and pedagogy (14) emphasize the need to analyze these tools' social and didactic impact beyond their technical functionality. Finally, areas such as learning analytics (11), data science (10), and machine learning (10) reinforce the trend towards the personalization of education through big data analysis.

The co-occurrence analysis of keywords in the literature (figure 3) reveals three central categories that structure the academic debate: personalization of learning, optimization of teaching time, and strengthening of executive functions. These dimensions reflect research priorities and the challenges and opportunities of integrating artificial intelligence in higher education.

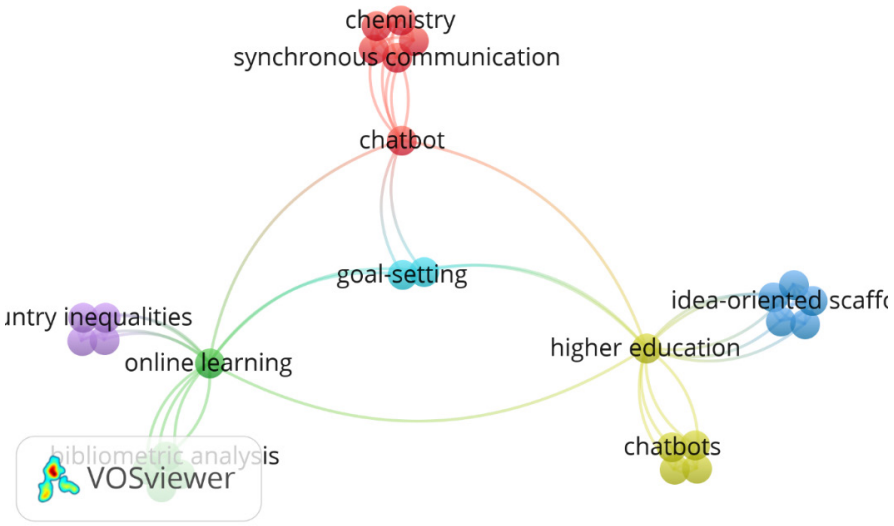

Figure 3. Cooccurrence analysis of keywords

Personalization of learning

The adaptability of AI systems emerges as a dominant theme, evidenced by terms such as intelligent tutoring system (2 occurrences, linking strength: 13), self-regulated learning (1, 5), and individual digital study assistant (1, 5). These concepts highlight the potential of AI to provide personalized learning paths supported by tools such as learning analytics (1, 5) and scaffolding (1, 5), which allow content to be adjusted according to individual progress. In addition, cognitive skills (1, 8) and multi-modal tasks (1, 8) suggest a focus on developing specific skills through diversified activities. At the same time, active learning (1, 4) and flipped learning (1, 4) underline methodologies prioritizing learner autonomy.

One of the most significant contributions of AI-based academic monitors, and widely proven in the literature, lies in their ability to personalize the learning process, adapting to the specific needs of each student.[15,16] These systems promise to use advanced algorithms to analyze individual performance in real time to identify strengths, weaknesses, and learning preferences.[17] By processing data, AI monitors dynamically adjust content, modify the pace of instruction, and even recommend supplementary resources that align with the learner's cognitive profile.[18,19] This adaptability optimizes assimilation and learning.

This adaptability optimizes knowledge assimilation and increases student engagement and motivation.[20] This evidence is provided by platforms such as ALEKS(Assessment and Learning in Knowledge Spaces), which uses item response theory models to design personalized learning paths in mathematics, leading to documented improvements in retention rates and academic performance.[21] These systems foster student agency by allowing them to make informed decisions about their learning journey.[22]

For example, some monitors feature interactive dashboards where students visualize their progress, set personal goals, and receive suggestions based on performance predictions.[23] Thus, AI-driven personalization redefines the relationship between teaching and learning, positioning students as active protagonists in their academic development.[24]

Optimization of teaching time

Efficiency in educational management is manifested in keywords such as chatbot (2 occurrences, linking strength: 9), online classes (1, 5), and teaching and learning (1, 5), which reflect the use of digital assistants to automate administrative tasks or basic feedback. The recurrence of higher education (3, 13) and online learning (3, 12) links these innovations to complex learning environments, where AI can ease the teaching load through automated assessment (1, 4) and instructional scaffolding (1, 5). However, critical success factors and challenges (1, 5) and ethics (1, 4) warn of the need to balance automation with human supervision.

Incorporating AI-based academic monitors has radically redefined time management in higher education by freeing faculty from administrative and operational burdens that traditionally consumed a significant portion of their day.[25] By delegating these functions to intelligent systems, faculty can refocus their efforts on more strategic dimensions of teaching, such as designing meaningful learning experiences, personalized mentoring, and facilitating critical discussions that foster complex thinking.[26,27]

A paradigmatic example of this optimization can be seen in educational chatbots integrated into platforms such as Moodle, which automatically respond to recurring student queries about deadlines, assessment criteria, or access to materials.[28,29] This streamlines communication and significantly reduces message saturation in teaching channels, allowing human interactions to be reserved for deep conceptual doubts or situations that require emotional intervention.[30]

In addition, AI has transformed formative assessment through systems that analyze patterns in student errors and generate detailed reports for the teacher.[8,31] Platforms such as Gradescope use pattern recognition algorithms to cluster similar responses in written assessments, allowing the teacher to provide consistent feedback in a fraction of the time it would take to do so manually.[32,33] This efficiency improves the quality of feedback students receive and allows educators to proactively identify group learning trends and adjust their teaching strategies.[34] This paradigm does not seek to replace the teacher as a teacher.

This paradigm seeks not to replace teachers but to enhance their role as intellectual guides and facilitators of deep learning.[35] By relieving them of mechanical tasks, AI monitors allow them to focus on pedagogical inspiration, the development of scientific curiosity, and the holistic formation of students as professionals and critical citizens.[36] The future challenge lies in strategically training teachers to manage these tools, ensuring that automation complements the humanistic essence of higher education.[37]

Strengthening executive functions

The development of metacognitive and executive skills is articulated through concepts such as goal-setting (1 occurrences, linking strength: 4), psychomotor skills (1, 8), and task analysis (1, 8), which denote the role of AI monitors in the planning and monitoring of academic activities. The co-occurrence of perceptual skills (1, 8) and collaborative problem-solving (1, 5) suggests that these systems also foster transversal competencies, while gritting (1, 5) and twenty-first-century skills (1, 4) point to their impact on student resilience and adaptability.

Added to this is the relevance of simulation-based training (1, 8), which illustrates practical applications for training executive functions in controlled environments.

The interconnection between these categories, exemplified by the linking force of terms such as artificial intelligence (1, 4) and intelligent tutoring system (2, 13), reveals a maturing field of research where AI acts as a bridge between pedagogical innovation and institutional efficiency. However, the marginal presence of privacy (1, 4) and policies (1, 4) warns of gaps in the normative framework. At the same time, mixed methods (1, 5) and systematic reviews (1, 4) highlight the need to address these issues with methodological rigor.

AI-based academic monitors have proven to be particularly effective tools for developing executive functions and essential cognitive skills in university students, including planning, self-regulation, inhibitory control, and metacognition.[38] These systems act as digital scaffolds that progressively guide students in autonomous learning management.[18,39] Like a human tutor, AI can identify the space between what the learner can achieve alone and what they can achieve with help by providing the right and necessary support at each stage.[40] AI is A key mechanism in this empowerment.

A key mechanism in this reinforcement is the implementation of incremental goal systems and smart reminders, which break down complex academic goals into achievable micro-tasks.[41] This approach improves temporal organization and reduces procrastination by making incremental progress visible, a critical factor according to studies on self-regulation in digital environments.[42]

In addition, the interactive progress panels incorporated in these systems serve a critical metacognitive function.[10] By providing real-time visualizations of performance, they facilitate students to reflect on their learning strategies and make conscious adjustments.[43,44] Research in neuroeducation highlights that this constant feedback strengthens the brain circuits associated with monitoring and evaluating one's performance and skills transferable to future professional contexts.[33]

It is significant to note how these digital monitors go beyond the traditional scaffolding model by incorporating adaptive gamification elements that enhance intrinsic motivation.[45] Systems such as Duolingo for Schools or maths platforms such as IXL Learning use algorithms that adjust the difficulty of challenges according to the threshold of ability detected in each user, maintaining an optimal balance between effort and achievement.[46,47] This mechanism, known in educational psychology as flow, correlates with measurable improvements in academic persistence and tolerance to frustration.[48]

However, the success of these tools depends critically on a design centered on the ethic of digital care, where technology promotes autonomy without generating dependency.[10,18] The challenge lies in creating systems that gradually transfer control to the learner, which prevents excessive external structuring from inhibiting self-management development.[49]

The implication of these advances transcends academia; by strengthening executive functions through personalized digital interactions, students are equipped with essential cognitive tools to navigate an increasingly complex and volatile professional world.[50,51] This positions AI monitors not as mere technical assistants but as catalysts for developing soft skills that traditional education has struggled to scale effectively.[29,52]

DISCUSSION

The emergence of AI-based academic monitors has revolutionized the concept of educational inclusion in higher education, overcoming traditional barriers to access and participation that have particularly affected vulnerable student populations.[6,53] These systems democratize academic support by offering personalized assistance 24/7, a critical factor for students who must juggle their studies with full-time jobs, family responsibilities, or reduced mobility. Unlike conventional tutoring services, which are limited by fixed schedules and human availability, AI-powered platforms ensure that no student is left behind due to extracurricular circumstances, adapting to the study rhythms and times each personal situation allows.[42]

A paradigmatic example of this equalizing potential is the Squirrel AI model in China. This platform has demonstrated how adaptive tutoring can dramatically reduce educational gaps in contexts of high socio-economic diversity.[54] Through a system that diagnoses in depth each user's specific learning styles and knowledge gaps, Squirrel AI has enabled students in rural areas with little access to qualified teachers to achieve results comparable to those of elitist urban schools.[55] This case shows how AI can compensate for structural inequalities when the technological design prioritizes adaptability over standardization.

The inclusive impact of these systems is further amplified for students with special educational needs, for whom digital monitors offer previously unthinkable solutions. Platforms such as Microsoft Reading Progress employ natural language processing to support students with dyslexia, automatically adjusting reading speed, font size, or line spacing according to each user's detected preferences.[56] Simultaneously, handwriting pattern analysis systems can identify early signs of learning difficulties even earlier than traditional assessments, enabling timely interventions.[57] These capabilities represent a quantum leap from traditional special education models, often limited by insufficient institutional resources and long diagnostic wait times.

However, the true measure of these inclusive technologies' success lies in their ability to prevent new forms

of digital exclusion.[58] This highlights the need to combine AI with AI to provide a more effective and efficient way to address the needs of children with special needs.

This highlights the need to combine AI with universal learning design, which ensures compatibility with low-cost, offline devices that prevent the marginalization of students with limited connectivity.[59] At the same time, developing algorithms free of cultural or gender bias is necessary as an ethical imperative, which merits assessing equity in AI-based education systems.[60]

Ultimately, the promise of these intelligent academic monitors transcends mere technical assistance. By providing personalized scaffolding on a mass scale, they not only level the playing field for historically marginalized populations but also challenge the traditional model that links educational quality to institutional resources. In this sense, AI monitors represent both a historic opportunity and a collective responsibility to build genuinely democratizing education systems.

CONCLUSIONS

The integration of AI-based academic monitors in higher education represents a turning point in 21st-century pedagogy. The findings presented confirm that these systems overcome the limitations of traditional models by offering adaptive learning, intelligent teaching support, and cognitive competence development on an unprecedented scale. Their value transcends operational efficiency by democratizing access to personalized tutoring and inclusive resources; they are redefining the principles of educational equity.

However, their implementation requires addressing critical challenges. On the one hand, it is essential to ensure algorithmic transparency to avoid bias and preserve student data privacy. On the other hand, the balance between automation and humanization of education must be maintained, where AI complements teacher guidance in aspects such as ethical training or critical thinking.

In perspective, these systems emerge as catalysts for a more flexible and inclusive educational paradigm capable of responding to the diversity of needs in globalized classrooms. Their success will depend on institutional policies prioritizing universal access and teacher training in digital skills. In this way, AI monitors will not only optimize educational processes but can become pillars for building university systems centered on the student's integral development. The future of higher education is not in technology per se but in how it humanizes it to serve transcendent pedagogical purposes.

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