Power System Protection and Control
ISSN:1674-3415

CHALLENGES AND TRENDS IN THE USE OF ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION, IMPACTS ON EDUCATIONAL QUALITY AND THE LEARNING EXPERIENCE: A BIBLIOMETRIC APPROACH

Barco Quiñonez Juan Carlos[1], Freire Lasso Johanna Mariela2
Macias Arroyo Franklin Gregorio[3], Lazo Sulca Rafael Seleyman[4]

[1]Universidad Estatal de Milagro, Milagro, Guayas (Ecuador), Ciudadela universitaria Km. 1.5 vía al Km. 26, jbarcoq@unemi.edu.ec
[2]Universidad Estatal de Milagro, Milagro, Guayas (Ecuador), Ciudadela universitaria Km. 1.5 vía al Km. 26, jlasso@unemi.edu.ec
[3]Universidad Estatal de Milagro, Milagro, Guayas (Ecuador), Ciudadela universitaria Km. 1.5 vía al Km. 26, gmaciasa@unemi.edu.ec
[4]Universidad Estatal de Milagro, Milagro, Guayas (Ecuador), Ciudadela universitaria Km. 1.5 vía al Km. 26, rlazos@unemi.edu.ec

Received:15 June 2025 **Revised**:18 July 2025 **Accepted**: 4 August 2025

***ABSTRACT*:**

The emergence of artificial intelligence (AI) in educational systems has radically transformed the dynamics of learning, assessment, and pedagogical management in higher education. In recent decades, the use of intelligent technologies has shifted from a futuristic promise to a tangible reality that directly influences the educational experience of both instructors and students. This study aims to answer the following question: Does co-occurrence network analysis allow for the identification of the challenges associated with the use of artificial intelligence in higher education and its impact on educational quality and the learning experience? To address this, a bibliometric co-occurrence network analysis was conducted on 1,642 conceptual terms proposed by 1,190 authors across 273 Q1-ranked journal articles. As a result, four main clusters were identified, each concentrating the majority of the conceptual terms: Cluster 1: Educational transformation and diversity in clinical environments mediated by artificial intelligence; Cluster 2: Language learning and emotional self-regulation supported by conversational AI; Cluster 3: Immersive and gamified environments for pedagogical innovation mediated by AI; Cluster 4: Learning analytics and intelligent algorithms applied to educational innovation in scientific disciplines. The findings highlight emerging research gaps that scholars in these areas may explore through advanced quantitative methodologies, such as factorial methods and structural equation modeling, as these clusters have the potential to evolve into mature constructs depending on their application

Keywords: *Artificial Intelligence, Higher Education, Educational Quality, Learning Experience, Bibliometrics, Python*.

INTRODUCTION

In the era of accelerated digitalization, artificial intelligence (AI) and the Internet of Things (IoT) have emerged as transformative technologies with a disruptive impact across multiple sectors, including higher education [1]. Their convergence has given rise to the emerging field of Artificial Intelligence of Things (AIoT), a powerful integration that enables the collection of environmental and behavioral data through interconnected sensors, the analysis of such data using intelligent algorithms, and the generation of automated, adaptive, and context-aware responses [2], [3]. In university settings, this synergy enables the real-time reconfiguration of the learning environment by integrating physical, cognitive, and emotional variables to enhance the educational experience and promote student well-being [4], [5].

From personalized learning to the development of smart classrooms, the potential of AIoT in higher education is immense [6]. It facilitates a shift from traditional pedagogical models, focused on homogeneous content delivery, toward responsive learning ecosystems, where devices monitor environmental quality (e.g., CO_2 levels, light, humidity, temperature), interpret student behavior patterns, and generate automated recommendations that optimize both teaching and learning [1], [7]. The study conducted by Tabuenca et al. (2024) demonstrates this approach in practice through the implementation of interactive dashboards, voice assistants, and gamified avatars that support pedagogical decision-making and promote environmental sustainability within the university classroom [5], [8].

However, the use of intelligent technologies in higher education is not without structural, ethical, and operational challenges. The integration of complex systems such as AIoT requires advanced technical competencies, adequate digital infrastructure, and clear protocols for the responsible use of data [9], [10]. In addition, concerns arise regarding student privacy, equitable access to technological resources, and the evolving role of educators in an increasingly automated environment [11], [12]. Despite these concerns, findings from pilot cases reveal the great potential of these technologies to foster personalized learning, environmental awareness, interdisciplinary collaboration, and the development of key digital and emotional competencies for the 21st century [6], [13].

This article addresses the challenges and trends associated with the integration of artificial intelligence in higher education, with particular emphasis on its impact on educational quality and the learning experience. Drawing on the analysis of three case studies, it examines the pedagogical, technical, and ethical implications of these advancements, as well as their practical applications in building more sustainable, interactive, and student-centered learning environments. The following sections explore the key aspects of this educational transformation, providing a critical framework for understanding how AIoT can help redefine the future of university education.

Integration of AIoT Systems in University Environments

The implementation of AIoT systems in higher education represents a structural transformation in the way learning spaces are conceived. These systems go beyond the use of conventional digital technologies by integrating physical devices, environmental sensors, algorithmic analysis, and intelligent feedback mechanisms within a single environment, as demonstrated in the university case study reported by Tabuenca et al. (2024) [5]. In this experiment, the Spike system was used to collect data over a three-month period on variables such as temperature, humidity, CO_2 levels, light intensity, and even the electrical activity of plants. These data were processed to anticipate potential risk conditions or environmental inefficiencies [14], [15].

The integration of these devices enabled the configuration of an interactive system composed of avatars (Plantagotchi), voice assistants, and intelligent dashboards that not only responded to environmental conditions but also generated real-time recommendations for students and instructors, such as opening windows, adjusting lighting, or regulating the use of air conditioning [16], [17]. This smart classroom model introduces a new dimension of educational sustainability by optimizing resources and promoting responsible behaviors through technology [18]. However, its large-scale adoption in universities requires overcoming barriers such as the digital skills gap among faculty, the need for continuous technical support, and the curricular integration of these tools to ensure their pedagogical relevance rather than merely serving decorative purposes [9], [19].

Personalized Learning through Predictive Analytics

One of the most significant contributions of AIoT in higher education is its ability to deliver personalized learning experiences through predictive models built from contextual data [20]. In the study, the researchers employed ARIMA models to anticipate the behavior of critical classroom variables, such as elevated carbon dioxide levels, sudden temperature fluctuations, or inadequate humidity for the plants present. These predictions were translated into concrete actions for students and instructors, such as ventilating the classroom, relocating plants, or reducing energy consumption [21].

This approach not only impacts the sustainability of the physical environment but also enables the design of differentiated learning pathways based on individual and group data collected by the sensors [22], [23]. For example, alerts can be generated based on the behavior of a specific group, or personalized recommendations can be configured according to each student's learning pace [24]. In the university context, this holds substantial value, as it respects students' varying levels of autonomy, study habits, and cognitive needs. Moreover, the use of interactive visualizations and voice assistants enhances data accessibility, allowing students to actively engage in monitoring their own learning and well-being [16], [25]. In sum, AIoT-based predictive analytics goes beyond educational diagnostics and positions itself as an anticipatory tool that is key to the continuous improvement of teaching and learning processes [14].

DOI: 10.46121/pspc.53.3.6

Transforming the Learning Experience through Intelligent Interfaces

The design of intelligent interfaces within AIoT systems is reshaping how students interact with their educational environments. Rather than relying solely on the instructor or static digital content, learning is mediated through conversational, visual, and affective tools that enhance and amplify the educational experience [26], [27]. The article highlights the use of an avatar called *Plantagotchi*, designed as a virtual creature whose well-being depends on the classroom's environmental conditions. This avatar functions as an emotional and motivational agent, encouraging students to adopt responsible attitudes toward the environment and establishing a symbolic connection between their behavior and the well-being of the surrounding ecosystem [14], [15].

The system also incorporates a voice assistant that allows users to query historical data such as temperature or light levels using natural language [28]. This component enhances accessibility, particularly for students with visual impairments or auditory preferences, and fosters the development of communication skills and critical thinking [29]. On the other hand, dashboard visualizations facilitate the understanding of patterns and trends, promoting a culture of evidence-based learning and informed decision-making [30].

These interfaces not only enhance students' cognitive and emotional engagement, but also position them as active agents within the educational ecosystem—capable of interpreting, intervening in, and transforming their own learning environments [31].

Ethical, Technical, and Pedagogical Challenges of Implementing AI in Higher Education

Despite its benefits, the implementation of AIoT systems in university settings presents significant challenges that must be addressed through institutional responsibility. First, there is growing concern regarding privacy and data protection, as these systems continuously collect information on environmental variables and, in some cases, on human presence or behavior within the classroom [10], [32]. Although the studies discussed in the article do not explicitly focus on this dimension, they acknowledge the need to consider ethical principles in the design and implementation of these technologies [12], [33].

Second, the effective use of these systems requires specialized technical training, which may pose a barrier for instructors with only basic levels of digital competence [9], [20]. The article notes that in undergraduate and graduate-level studies, instructors required external technical support to properly configure and use the system, highlighting the need to strengthen institutional capacities for the autonomous and sustained integration of AIoT technologies [34].

From a pedagogical perspective, questions also arise regarding the role of educators in highly automated environments: How can human intervention be balanced with decisions suggested by artificial intelligence? What kind of support does a student need when learning in a sensor- and algorithm-driven environment? These questions pave the way for a deeper reflection on the meaning, limitations, and possibilities of artificial intelligence in education [35]. In this regard, the article suggests a progressive integration approach focused on student well-being, environmental sustainability, and the development of critical digital competencies for contemporary society [30].

Applications of the PRISMA Methodology in the Field of Artificial Intelligence, Higher Education, and Its Impact on Educational Quality and Learning Experience

The PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) has gained wide recognition as a rigorous tool for the collection, selection, and analysis of scientific literature in complex and multidisciplinary contexts [36]. In the emerging field that integrates artificial intelligence (AI), higher education, and educational quality, PRISMA enables the structuring of systematic reviews that ensure transparency, reproducibility, and traceability in the identification of relevant studies [37]. This is particularly crucial given the growing proliferation of research on AI applications in the university context, ranging from recommendation systems for adaptive learning to intelligent assessment platforms and predictive analytics for academic performance [38].

Applying PRISMA in this context not only facilitates the organization and synthesis of available empirical evidence, but also enables the identification of gaps in the literature and emerging trends, such as personalized learning through educational analytics and the impact of virtual assistants on the student experience [39]. According to the bibliographic analysis of the base document, PRISMA has been instrumental in mapping how AI has established itself as a transformative tool in higher education, driving pedagogical innovation and reshaping

DOI: 10.46121/pspc.53.3.6

teaching and learning environments [40]. Moreover, the use of PRISMA enables the comparison of interventions and the measurement of their impact in terms of improving educational quality, accessibility, student satisfaction, and skills development. In this regard, it becomes a strategic methodology for informing decision-making in educational policy and technological development within higher education institutions [41].

Previous Bibliometric Studies Related to Artificial Intelligence, Higher Education, and Their Impact on Educational Quality and Learning Experience

Bibliometric research has increasingly enabled the mapping of the development of artificial intelligence (AI) within the field of higher education, evaluating both the volume of publications and the emerging thematic foci, as well as their impact on educational quality [42]. Several studies have employed bibliometric methodologies to identify the main lines of research, the most influential authors, collaboration networks, and the chronological evolution of scientific production within this interdisciplinary field [43]. One of the recurring findings is the centrality of topics such as personalized learning, intelligent tutoring systems, virtual assistants, and the use of big data for pedagogical decision-making.

For example, some of the analyzed abstracts highlight the proliferation of publications on AI-based tools aimed at improving academic performance and reducing university dropout rates [44]. Other studies emphasize sentiment analysis and text mining applied to teaching platforms as a means to optimize student feedback and monitor the learning experience in real time. Additionally, thematic clusters have been identified around AI ethics in educational settings, the design of adaptive environments, and the automated assessment of learning.

Taken together, these bibliometric studies provide a solid foundation for understanding how artificial intelligence is shaping educational practices in universities, while also allowing for the identification of research gaps and new opportunities to develop more efficient, personalized, and student-centered pedagogical approaches.

Therefore, this study poses the following research question: *Can co-occurrence network analysis identify the challenges associated with the use of artificial intelligence in higher education and its impact on educational quality and the learning experience?* Based on this question, we propose the following hypothesis:

H1: Co-occurrence network analysis of terms enables the identification of the challenges in the use of artificial intelligence in higher education, as well as its impact on educational quality and the learning experience.

In the context of the growing digitalization of higher education, artificial intelligence (AI) has emerged as a strategic tool for transforming teaching and learning processes. Its applications range from content personalization to the automation of assessment, directly impacting educational quality and the student experience. However, this adoption also presents significant challenges that must be systematically identified and understood to ensure its effective and ethical implementation.

The hypothesis of the present study that co-occurrence network analysis enables the identification of challenges associated with the use of artificial intelligence in higher education, as well as its impact on educational quality and the learning experience is grounded in the capacity of bibliometric methodologies to systematically map scientific knowledge. Co-occurrence analysis, in particular, allows for the visualization of emerging patterns in academic literature by clustering concepts that frequently appear together in titles, abstracts, and keywords, thereby revealing meaningful thematic connections.

Recent publications reflect a growing interest within the scientific community in topics such as educational automation, AI ethics, algorithm-mediated curricular adaptation, learning analytics, and the enhancement of pedagogical interaction through intelligent agents. The recurrent and co-occurring presence of these elements alongside terms such as *educational quality*, *engagement*, *student experience*, and *institutional challenges* confirms the relevance of co-occurrence analysis as a technique for identifying key issues.

Moreover, preliminary data indicate that the challenges associated with the use of AI are not solely technological in nature, but also pedagogical, ethical, and organizational. Network analysis enables the identification of how these challenges are interrelated and how they are positioned within the current academic discourse based on their connections to dimensions such as equitable access, algorithmic transparency, teacher training, and the critical evaluation of AI-mediated learning.

Power System Protection and Control
ISSN:1674-3415

Therefore, this hypothesis is not only valid but also necessary, as the bibliometric approach using co-occurrence analysis allows not only for the quantification of scientific output but also for the qualification of the conceptual relationships underlying the main challenges and opportunities that AI presents for the future of higher education.

METHODOLOGY

Document Selection

The selection of documents was carried out following the best practices outlined in the PRISMA methodology (see Figure 1). Two of the most prestigious databases Scopus and Web of Science were defined as the sources for the documents.To extract the relevant literature, search equations were structured according to the research topic and the technical requirements specified by each database (see Table 1).

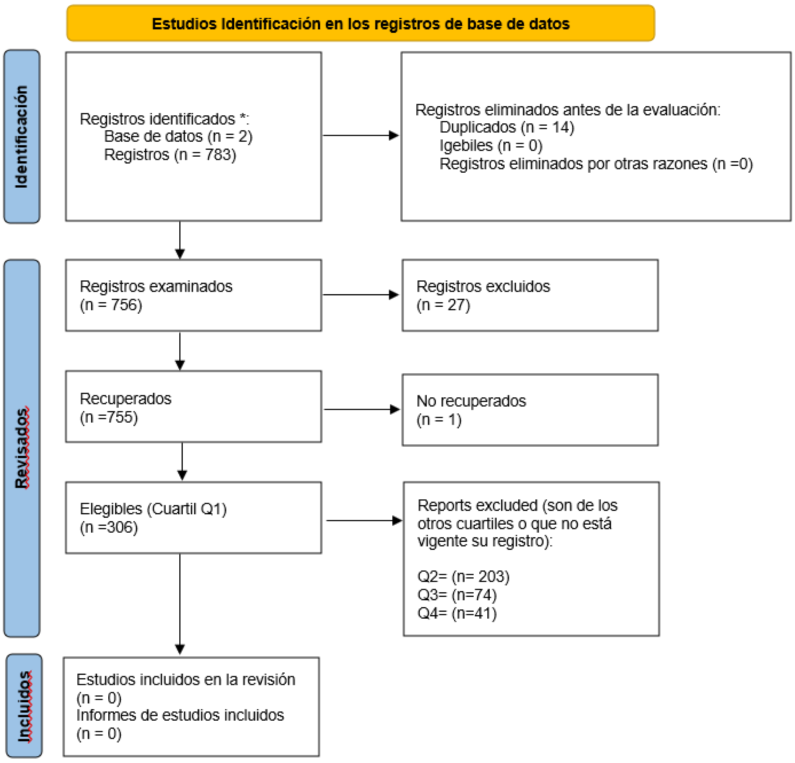


Figure 1. PRISMA Flow diagram

Table 1. Search Equiation

Data base	Search Equation	T. Doc
Scopus	TITLE-ABS-KEY (("artificial intelligence" OR "AI") AND ("higher education" OR "university") AND ("learning experience" OR "educational quality")) AND (LIMIT-TO (DOCTYPE , "ar"))	490
	"artificial intelligence" OR "AI" (All Fields) and "higher education" OR "university") (All Fields) And "learning experience" OR "educational quality" (All Fields) Document Type: Article	293
Total		783

Workflow Developed for the Bibliometric Analysis

To conduct the co-occurrence analysis of conceptual terms defined by the authors, the following workflow was developed:

1. Documents were extracted from the selected databases in .bib format, resulting in a total of 783 records.

Power System Protection and Control
ISSN:1674-3415

2. A Python script was developed to integrate and clean duplicate records, generating a single .bib file.
3. Another Python script was used to extract records corresponding to journals ranked in Q1, yielding a total of 273 documents.
4. To explore the main bibliometric indicators, the Bibliometrix package version 5.0 for R (version 4.5.1) was employed.
5. To generate the co-occurrence network graph, the software VOSviewer version 1.6.20 was used.
6. A Python script was developed to extract the clusters defined by the co-occurrence network in. json format and convert them to Excel.
7. Finally, a Python script was used to select the articles associated with the top four clusters concentrating the conceptual terms, in order to conduct the literature review.

RESULTS

Analysis of Key Bibliometric Indicators

The bibliometric analysis of the collected body of literature on artificial intelligence (AI) in the context of higher education reveals a sustained growth trend and increasing interest in the scientific production within this field. The study covers the period from 2000 to 2025 (see Figure 2A), during which a total of 273 documents were identified, originating from 112 sources.

The annual growth rate of scientific production is 21.03%, indicating a significant increase in publications on the topic, particularly over the past decade. This growth pattern can be attributed to the accelerated integration of AI-based technologies in educational settings, as well as to the global debate surrounding their impact on the quality and equity of learning (see Figure 2B).

The average age of the documents is just 1.4 years, reflecting the high recency of the studies analyzed. This indicates that the field is both emerging and dynamic, with a growing body of recent literature. Additionally, the average number of citations per document is 13.48, demonstrating a considerable degree of academic impact and visibility (see Figure 2C).

The analyzed documents cite a total of 7,189 references, reinforcing the robustness of the corpus and its connection to prior research, while also indicating an active scientific dialogue. From a thematic perspective, the analysis revealed 1,085 indexed terms (*Keywords Plus*) and 1,642 author-provided keywords (see Figure 2D), suggesting significant conceptual diversity. This terminological variety reflects an interdisciplinary field where perspectives from pedagogy, technology, ethics, institutional management, and learning analytics converge.

Regarding authorship, a total of 1,190 authors were identified, with only 29 single-authored documents, resulting in an average of 4.94 co-authors per publication. This pattern reflects a strong tendency toward collaborative research; however, it is noteworthy that no international collaborations were reported (0%), which may be considered a limitation in terms of geographic diversity and global inter-institutional cooperation.

Taken together, these bibliometric indicators suggest that the study of artificial intelligence in higher education represents a rapidly expanding field, characterized by a solid foundation of scientific production, a predominantly collaborative approach, and a strong focus on current and innovative themes. This quantitative foundation will be essential for the subsequent qualitative analyses—such as co-occurrence networks—which will help identify the main challenges, approaches, and trends shaping the contemporary academic discourse on the impact of AI on educational quality and the learning experience.

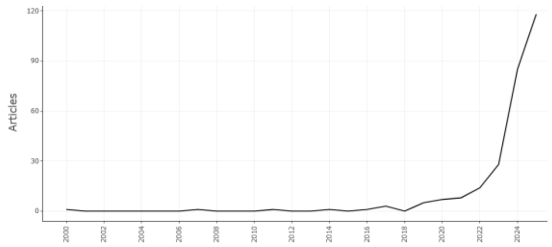
Figure 2. ***Análisis de las medidas bibliométricas***

A

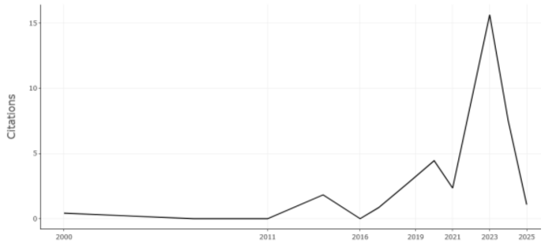
DOI: 10.46121/pspc.53.3.6

Power System Protection and Control
ISSN:1674-3415

B



C



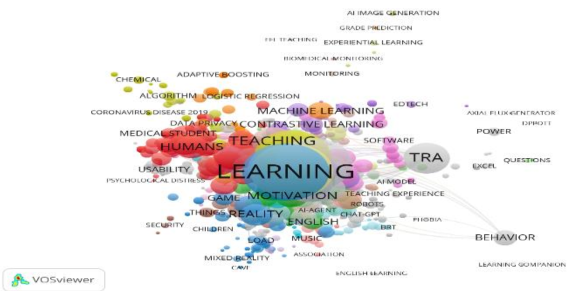
D

Note: A) Main Information. B) Annual Scientific Production. C) Average Citations Per Year. D) Word Cloud

Co-Occurrence Network Analysis of Conceptual Terms

The co-occurrence network analysis of conceptual terms was constructed from 1,642 terms identified across 273 articles (see Figure 3). Based on the network-defined clusters, four clusters were selected that concentrated the majority of the terms. The first cluster was labeled: Educational Transformation and Diversity in Clinical Settings Mediated by Artificial Intelligence. The second cluster was titled: Language Learning and Emotional Self-Regulation Mediated by Conversational Artificial Intelligence. The third cluster was named: Immersive and Gamified Environments for Pedagogical Innovation Mediated by Artificial Intelligence. The fourth cluster was defined as: Learning Analytics and Intelligent Algorithms Applied to Educational Innovation in Scientific Disciplines. The following section presents a literature review for each of these clusters.

Figure 3. ***Red de co ocurrencia de términos***



Cluster 1: Educational Transformation and Diversity in Clinical Settings Mediated by Artificial Intelligence

This cluster includes studies examining how artificial intelligence (AI) is being integrated into higher education in fields such as medicine, nursing, and pharmacy, through formats that promote clinical simulation, problem-based learning, and automated decision-making. Additionally, the presence of terms such as *diversity*, *minority*

DOI: 10.46121/pspc.53.3.6

groups, and *psychological distress* indicates a growing interest in the impact of AI on diverse student populations and their well-being.

In this regard, AI represents not only a tool for optimizing clinical teaching but also a challenge in terms of equity, personalization, and educational ethics (see Figure 4A).

Cluster 1 encompasses research focused on the convergence of medical education, artificial intelligence (AI), and diversity in clinical settings, revealing a significant shift from traditional training models. In this context, there is a growing interest in the use of intelligent technologies to enhance the quality of clinical learning, promote educational equity, and ensure the inclusion of diverse populations. The analyzed studies demonstrate how AI is being used as a supportive tool for both students and healthcare professionals, offering personalized resources, advanced clinical simulations, and adaptive assessment systems that enable more efficient, accurate, and culturally, cognitively, and gender-sensitive teaching [45], [46].

A notable trend within this cluster is the use of machine learning algorithms and natural language processing systems to analyze clinical performance data, identify knowledge gaps, and recommend individualized learning pathways. This approach not only optimizes training time but also addresses the specific needs of students with varying levels of experience, technical skills, and learning styles [47], [11]. Moreover, the integration of immersive technologies, such as augmented reality and virtual reality, facilitates the recreation of complex and varied clinical scenarios, which is essential for preparing future professionals to face the diverse healthcare contexts they will encounter in real-world practice [48], [49].

The inclusive dimension of this cluster is also reflected in studies that highlight the role of AI in detecting biases and inequalities in clinical education. For instance, some works apply predictive models to assess the impact of sociocultural factors on academic performance and student engagement, proposing data-driven strategies to ensure equitable opportunities for access, retention, and academic success [50], [51]. This analytical approach paves the way for more equitable and transparent educational systems, aligned with the principles of social justice and medical ethics.

In addition, interdisciplinary initiatives have been identified that integrate engineering, medicine, pedagogy, and data science to design hybrid clinical-educational environments. These proposals aim to transform training spaces into dynamic, adaptive, and intelligent environments where students acquire not only technical competencies but also soft skills, critical thinking, and intercultural sensitivity [52], [53].

Taken together, Cluster 1 reveals a paradigmatic transformation in clinical education, in which artificial intelligence serves as a catalyst for innovation, inclusion, and educational quality. This new training model, grounded in empirical evidence and the analytical potential of AI, contributes to the development of healthcare professionals who are better prepared, more empathetic, and highly competent in increasingly diverse and demanding contexts.

Cluster 2: Language Learning and Emotional Self-Regulation Mediated by Conversational Artificial Intelligence

This cluster comprises studies that explore how AI-based technologies particularly conversational chatbots and generative AI tools are transforming foreign language learning in school and university settings. Concepts such as self-efficacy, motivation, anxiety, and satisfaction emerge as key factors in the impact of these technologies, reflecting a focus on the emotional dimension of the learning experience.

A mixed-methods approach is also observed, with an emphasis on student perceptions, language performance, and the development of communicative skills. This points to a research trend centered on the student as an active agent mediated by AI (see Figure 4B).

Cluster 2 brings together studies focused on the intersection of foreign language learning, the development of emotional skills, and the use of conversational artificial intelligence as a pedagogical mediator. This thematic line emerges as an innovative response to contemporary challenges in language instruction, by integrating technologies that personalize the learning experience, enhance intrinsic motivation, and foster emotional self-regulation particularly in digitized and multicultural educational contexts [54], [55].

DOI: 10.46121/pspc.53.3.6

One of the main contributions of this cluster is the integration of intelligent conversational agents chatbots that interact with students in real time facilitating learning through structured dialogues, personalized recommendations, and emotional feedback. These platforms, powered by natural language processing algorithms, not only correct grammatical or pronunciation errors but also monitor affective indicators such as frustration, anxiety, or lack of motivation, dynamically adjusting the interaction to sustain student engagement [56], [57]. Thus, conversational artificial intelligence emerges as a tool that supports both linguistic progress and the user's emotional well-being.

In addition, the studies within this cluster highlight the value of AI-mediated virtual environments for language practice in simulated contexts. Through immersive scenarios, students can engage in authentic communicative situations without fear of external judgment, thereby reducing affective barriers and reinforcing confidence in using the new language [11], [15]. This socio-emotional dimension is closely linked to autonomous learning strategies, in which students regulate their own pace, select relevant content, and monitor their performance key aspects for meaningful learning in non-presential environments.

On the other hand, there is an emphasis on the emotionally sensitive design of conversational systems. Several studies address the development of empathetic chatbots capable of recognizing emotional patterns in user language and responding adaptively, integrating principles of positive psychology and affective learning [58], [59]. This trend points toward the creation of educational assistants that are not only functional but also human-centered in their interactions, capable of fostering trust and providing support throughout the learning process.

Finally, Cluster 2 evidences a shift toward student-centered teaching models, where artificial intelligence does not replace the instructor but rather amplifies their capabilities and facilitates more inclusive, interactive, and emotionally balanced education. Within this framework, language learning is reconfigured as a comprehensive process encompassing not only linguistic competence but also emotional regulation, autonomy, and resilience in the face of digital learning challenges.

Cluster 3: Immersive and Gamified Environments for Pedagogical Innovation Mediated by Artificial Intelligence

This cluster represents a convergence of immersive technology, innovative instructional design, and AI-based pedagogical assessment. The prominent presence of terms such as *virtual reality*, *game-based learning*, *formative assessments*, and *learning performance* reflects a rapidly evolving field in which artificial intelligence integrates with simulated environments, multisensory experiences, and gamification dynamics to optimize learning and enable more interactive and adaptive assessment.

These approaches address both technical challenges such as cognitive load and technological suitability and pedagogical challenges such as motivation, feedback, and student-centered design (see Figure 4C).

Cluster 3 groups research focused on the integration of immersive environments and educational gamification, powered by artificial intelligence (AI), as key strategies to promote pedagogical innovation in digital teaching and learning contexts. This interdisciplinary approach highlights AI's capacity to energize active methodologies, enrich student interaction, and personalize learning experiences through emerging technologies such as virtual reality (VR), augmented reality (AR), and adaptive learning systems [11], [60].

A prominent trend within this cluster is the development of gamified educational platforms that utilize intelligent algorithms to adjust difficulty levels, suggest personalized challenges, and monitor student progress in real time. These platforms not only enhance extrinsic motivation through virtual rewards and leaderboards but also reinforce intrinsic motivation by offering immersive scenarios that simulate real or fantastical situations, where errors become opportunities for learning and exploration [19], [50], [61].

AI-mediated immersive environments enable a break from the linearity of traditional curricula, offering flexible learning pathways where students can make decisions, explore multiple solutions, and receive immediate feedback. This structure fosters critical thinking, creative problem-solving, and meaningful learning skills especially valued in 21st-century competency development [47], [48]. Additionally, the adaptive design of these experiences accommodates diverse cognitive styles and prior knowledge levels, thereby enhancing educational inclusion.

DOI: 10.46121/pspc.53.3.6

From a technological perspective, studies within the cluster emphasize the role of AI in analyzing behavioral patterns within gamified environments. Intelligent systems collect data on choices, response times, navigation paths, and engagement levels to generate learning profiles and automatically adjust proposed challenges. This continuous feedback mechanism enhances pedagogical personalization and promotes student-centered learning [18], [62].

Successful experiences in primary, secondary, and higher education are also highlighted, where virtual worlds, 3D simulations, and AI-powered avatars capable of interacting with, guiding, and non-intrusively assessing students are implemented. These scenarios increase social presence, sense of agency, and emotional immersion key factors for achieving lasting learning outcomes [63], [34].

In summary, Cluster 3 demonstrates how immersive and gamified environments powered by artificial intelligence represent not only a transformation in teaching methods but also in the way learning occurs. This technological-pedagogical convergence inaugurates a new educational paradigm based on experience, adaptability, emotion, and play, responding to the demands of an ever-evolving educational ecosystem.

Cluster 4: Learning Analytics and Intelligent Algorithms Applied to Educational Innovation in Scientific Disciplines
This cluster reflects a clear intersection between advanced artificial intelligence (AI, adaptive algorithms, neural networks, data mining) and its direct application in higher education within science and technology fields. The use of tools such as learning analytics and data mining enables the transformation of instructional design, the evaluation of student performance, the personalization of learning strategies, and the enhancement of evidence-based teaching.

Moreover, the presence of fields such as bioinformatics, chemistry, epidemiology, pharmacoeconomics, and water management suggests that AI is being utilized not only as a subject of study but also as a cross-cutting tool for pedagogical innovation in STEM (Science, Technology, Engineering, and Mathematics) education (see Figure 4D).

Cluster 4 centers on the use of learning analytics and intelligent algorithms as catalysts for pedagogical innovation in scientific fields such as biology, chemistry, physics, mathematics, and computer science. This line of research demonstrates how leveraging large datasets generated by virtual learning environments, combined with the predictive capabilities of artificial intelligence (AI), enables the transformation of traditional educational models into more precise, adaptive, and student performance-oriented approaches [1], [10], [64].

A central focus of this cluster is the design of educational analytics platforms that process information on interactions, response times, navigation paths, and achievement levels to generate individualized feedback for both instructors and students. This data-driven approach enables the identification of learning patterns, the anticipation of low-performance risks, and the design of timely and contextualized pedagogical interventions [65], [50]. In particular, the use of intelligent dashboards has gained prominence as a real-time decision-making visual tool, thereby enhancing instructors' capacity for personalized support.

Asimismo, el clúster incluye investigaciones que aplican algoritmos de aprendizaje automático (machine learning) para evaluar y predecir el desempeño en disciplinas científicas, donde los niveles de abstracción y la complejidad de los contenidos suelen ser altos. Mediante modelos supervisados y no supervisados, los sistemas pueden clasificar perfiles de estudiantes, sugerir recursos didácticos adecuados y hasta simular trayectorias educativas personalizadas que potencien el aprendizaje autónomo y significativo [11], [19], [66].

Another notable contribution of this cluster is the use of expert systems and AI-powered virtual assistants that support students in solving scientific problems, explain complex concepts through natural language, and provide activities tailored to the learner's level of understanding. These solutions, integrated within digital platforms, promote equitable access to scientific content and foster the development of key competencies such as logical reasoning, scientific argumentation, and virtual experimentation [7], [54].

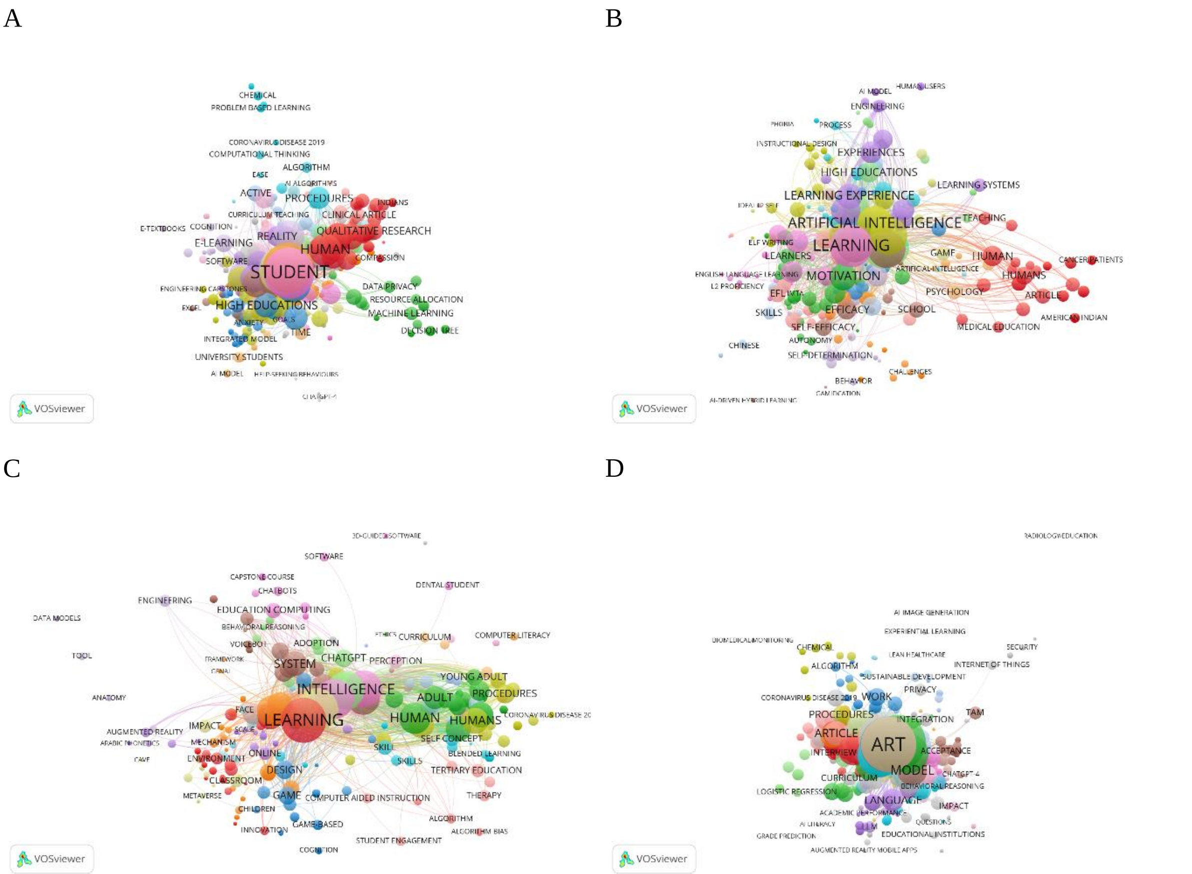
Furthermore, the studies reflect how learning analytics integrates with innovative pedagogical frameworks such as project-based learning, flipped classrooms, and collaborative learning, enhancing their effectiveness by providing empirical evidence of their impact. Artificial intelligence thus becomes not only a technological tool

DOI: 10.46121/pspc.53.3.6

but also an epistemological support that redefines the role of the instructor as a mediator and the student as an active knowledge constructor [2], [9].

Taken together, Cluster 4 highlights a substantive transformation in the teaching of scientific disciplines, characterized by the strategic use of data and algorithms to personalize instruction, optimize assessment processes, and elevate learning quality. This trend positions artificial intelligence as a key ally in the evolution of 21st-century STEM educational models.

Figure 4. **Cluster de mayor concentración de términos conceptuales**



Note: A) Educational Transformation and Diversity in Clinical Settings Mediated by Artificial Intelligence, B) Language Learning and Emotional Self-Regulation Mediated by Conversational Artificial Intelligence, C) Immersive and Gamified Environments for Pedagogical Innovation Mediated by Artificial Intelligence, D) Learning Analytics and Intelligent Algorithms Applied to Educational Innovation in Scientific Disciplines

CONCLUSION

The incorporation of artificial intelligence in higher education, especially through AIoT systems, represents a structural, pedagogical, and technological revolution in how university learning environments are conceived, designed, and managed. This study has demonstrated that the combined use of sensors, intelligent algorithms, and adaptive platforms not only optimizes the physical classroom environment but also personalizes educational processes, enriches the student experience, and fosters key 21st-century competencies such as emotional self-regulation, critical thinking, environmental awareness, and digital literacy.

Findings derived from the bibliometric and co-occurrence analyses reveal four emerging thematic clusters that frame the contemporary academic debate: educational transformation in diverse clinical contexts; emotionally mediated language learning; pedagogical innovation based on immersive and gamified environments; and the use

DOI: 10.46121/pspc.53.3.6

of learning analytics and intelligent algorithms in scientific disciplines. These clusters not only reflect the practical applications of AI in education but also highlight the ethical, technical, and training challenges that must be addressed to ensure effective, equitable, and sustainable implementation.

Furthermore, the application of systematic methodologies such as PRISMA and bibliometric analysis techniques has allowed for the clear identification of research trends, conceptual gaps, and future opportunities in this field. The co-occurrence network approach proves to be a strategic tool for mapping knowledge and supporting academic, institutional, and educational policy decisions. Collectively, the results of this research offer a comprehensive framework to understand and guide the AI-driven educational transformation, promoting a more inclusive, adaptive, and student-centered university model.

REFERENCES

1. E. S. Adabor, E. Addy, N. Assyne, y E. Antwi-Boasiako, «Enhancing sustainable academic course delivery using AI in technical universities: An empirical analysis using adaptive learning theory», Sustainable Futures, vol. 10. 2025. doi: 10.1016/j.sftr.2025.100828.
2. B. N. Abbasi, Y. Wu, y Z. Luo, «Exploring the impact of artificial intelligence on curriculum development in global higher education institutions», Education and Information Technologies, vol. 30, n.o 1. pp. 547-581, 2025. doi: 10.1007/s10639-024-13113-z.
3. D. Darmawansah, G.-J. Hwang, C.-J. Lin, y F. Febiyani, «An artificial intelligence-supported GFCA learning model to enhance L2 students’ role-play performance, English speaking and interaction mindset», Educational Technology Research and Development. 2025. doi: 10.1007/s11423-025-10453-6.
4. A. Abulibdeh, C. Baya Chatti, A. Alkhereibi, y S. El Menshawy, «A Scoping Review of the Strategic Integration of Artificial Intelligence in Higher Education: Transforming University Excellence Themes and Strategic Planning in the Digital Era», European Journal of Education, vol. 60, n.o 1. 2025. doi: 10.1111/ejed.12908.
5. A. Fernández-Sánchez, J. J. Lorenzo-Castiñeiras, y A. Sánchez-Bello, «Navigating the Future of Pedagogy: The Integration of AI Tools in Developing Educational Assessment Rubrics», European Journal of Education, vol. 60, n.o 1. 2025. doi: 10.1111/ejed.12826.
6. S. Almuqhim y J. Berri, «AI-Driven Personalized Microlearning Framework for Enhanced E-Learning», Computer Applications in Engineering Education, vol. 33, n.o 3. 2025. doi: 10.1002/cae.70040.
7. Y. H. Al-Mamary y A. A. Abubakar, «Empowering ChatGPT adoption in higher education: A comprehensive analysis of university students’ intention to adopt artificial intelligence using self-determination and technology-to-performance chain theories», Internet and Higher Education, vol. 66. 2025. doi: 10.1016/j.iheduc.2025.101015.
8. A. S. Almogren, «Creating a Novel Approach to Examine How King Saud University’s Arts College Students Utilize AI Programs», IEEE Access, vol. 13. pp. 63895-63917, 2025. doi: 10.1109/ACCESS.2025.3553631.
9. A. Atta, M. Esmat, N. Amasha, E. Elayat, y W. K. Elsaid, «A Smart ChatGPT Mobile Application for Improving C# Programming Skills for Students in Educational Institutions», Qubahan Academic Journal, vol. 5, n.o 2. pp. 49-62, 2025. doi: 10.48161/qaj.v5n2a1772.
10. E. Bauer et al., «Personalizing simulation-based learning in higher education», Learning and Individual Differences, vol. 122. 2025. doi: 10.1016/j.lindif.2025.102746.

11. Y. Bai y S. Wang, «Impact of generative AI interaction and output quality on university students' learning outcomes: a technology-mediated and motivation-driven approach», Scientific Reports, vol. 15, n.o 1. 2025. doi: 10.1038/s41598-025-08697-6.
12. P. Cabrera-Solano, C. Ochoa-Cueva, y L. Castillo-Cuesta, «Enhancing EFL Higher Education through Fliki Videos: An Artificial Intelligence Implementation Approach», World Journal of English Language, vol. 15, n.o 1. pp. 424-433, 2025. doi: 10.5430/wjel.v15n1p424.
13. L. Cai, M. M. Msafiri, y D. Kangwa, «Exploring the impact of integrating AI tools in higher education using the Zone of Proximal Development», Education and Information Technologies, vol. 30, n.o 6. pp. 7191-7264, 2025. doi: 10.1007/s10639-024-13112-0.
14. M. Doğan, A. Celik, y H. Arslan, «AI In Higher Education: Risks and Opportunities From the Academician Perspective», European Journal of Education, vol. 60, n.o 1. 2025. doi: 10.1111/ejed.12863.
15. D. M. Gezgin y T. Türk Kurtça, «Developing the AIessphobia in education scale and examining its psychometric characteristics», Education and Information Technologies, vol. 30, n.o 4. pp. 4471-4491, 2025. doi: 10.1007/s10639-024-12984-6.
16. X. Du, M. Du, Z. Zhou, y Y. Bai, «Facilitator or hindrance? The impact of AI on university students' higher-order thinking skills in complex problem solving», International Journal of Educational Technology in Higher Education, vol. 22, n.o 1. 2025. doi: 10.1186/s41239-025-00534-0.
17. B. Han, S. Nawaz, G. Buchanan, y D. McKay, «Students' Perceptions: Exploring the Interplay of Ethical and Pedagogical Impacts for Adopting AI in Higher Education», International Journal of Artificial Intelligence in Education. 2025. doi: 10.1007/s40593-024-00456-4.
18. A. Hassoulas et al., «A pilot study investigating the efficacy of technology enhanced case based learning (CBL) in small group teaching», Scientific Reports, vol. 15, n.o 1. 2025. doi: 10.1038/s41598-025-99764-5.
19. A. Ghimire y Y. Qiu, «Redefining pedagogy with artificial intelligence: How nursing students are shaping the future of learning», Nurse Education in Practice, vol. 84. 2025. doi: 10.1016/j.nepr.2025.104330.
20. M. Jaboob, M. Hazaimeh, y A. M. Al-Ansi, «Integration of Generative AI Techniques and Applications in Student Behavior and Cognitive Achievement in Arab Higher Education», International Journal of Human-Computer Interaction, vol. 41, n.o 1. pp. 353-366, 2025. doi: 10.1080/10447318.2023.2300016.
21. B. Czerkawski, «AI and the Learning Experience Design: From Divergent Creativity to Convergent Precision», TechTrends, vol. 69, n.o 2. pp. 260-270, 2025. doi: 10.1007/s11528-024-01032-2.
22. F. Khanipoor y Z. Karimian, «Unleashing the power of data: the promising future of learning analytics in medical education: a commentary», Education and Information Technologies, vol. 30, n.o 8. pp. 10373-10380, 2025. doi: 10.1007/s10639-024-13273-y.
23. B. Kanoksilapatham y T. Takrudkaew, «Integrating ChatGPT to Enhance University Students'Communication Skills: Pedagogical Considerations», World Journal of English Language, vol. 15, n.o 6. pp. 173-183, 2025. doi: 10.5430/wjel.v15n6p173.

24. A. K. Khoso, W. Honggang, y M. A. Darazi, «Empowering creativity and engagement: The impact of generative artificial intelligence usage on Chines EFL students' language learning experience», Computers in Human Behavior Reports, vol. 18. 2025. doi: 10.1016/j.chbr.2025.100627.
25. M. A. S. Khasawneh, A. Aladini, S. A. Assi, y B. Ajanil, «Portfolio assessment in AI-enhanced learning environments: a pathway to emotion regulation, mindfulness, and language learning attitudes», Language Testing in Asia, vol. 15, n.o 1. 2025. doi: 10.1186/s40468-025-00345-0.
26. S. Moghavvemi y F. A. Jam, «Unraveling the influential factors driving persistent adoption of ChatGPT in learning environments», Education and Information Technologies. 2025. doi: 10.1007/s10639-025-13662-x.
27. A. Maulana, R. M. Fenitra, S. Sutrisno, y Kurniawan, «Artificial intelligence, job seeker, and career trajectory: How AI-based learning experiences affect commitment of fresh graduates to be an accountant?», Computers and Education: Artificial Intelligence, vol. 8. 2025. doi: 10.1016/j.caeai.2025.100413.
28. W. K. Monib, A. Qazi, y M. M. Mahmud, «Exploring learners' experiences and perceptions of ChatGPT as a learning tool in higher education», Education and Information Technologies, vol. 30, n.o 1. pp. 917-939, 2025. doi: 10.1007/s10639-024-13065-4.
29. A. Nguyen, F. Gul, B. Dang, L. Huynh, y T. Tuunanen, «Designing embodied generative artificial intelligence in mixed reality for active learning in higher education», Innovations in Education and Teaching International. 2025. doi: 10.1080/14703297.2025.2499177.
30. L. Symeou, L. Louca, A. Kavadella, J. Mackay, Y. Danidou, y V. Raffay, «Development of Evidence-Based Guidelines for the Integration of Generative AI in University Education Through a Multidisciplinary, Consensus-Based Approach», European Journal of Dental Education, vol. 29, n.o 2. pp. 285-303, 2025. doi: 10.1111/eje.13069.
31. C. B. Omeh, C. J. Olelewe, y I. B. Ohanu, «Impact of Artificial Intelligence Technology on Students' Computational and Reflective Thinking in a Computer Programming Course», Computer Applications in Engineering Education, vol. 33, n.o 3. 2025. doi: 10.1002/cae.70052.
32. A. Raptopoulou, «ChatGPT in Higher Education: Supporting Academic Literacy Through ChatGPT-Based Activities», European Journal of Education, vol. 60, n.o 2. 2025. doi: 10.1111/ejed.70131.
33. M. Parviz y F. Arthur, «Exploring EFL Teachers' Behavioral Intentions to Integrate GenAI Applications: Insights From PLS-SEM and fsQCA», Human Behavior and Emerging Technologies, vol. 2025, n.o 1. 2025. doi: 10.1155/hbe2/5582099.
34. D. Ravšelj et al., «Higher education students' perceptions of ChatGPT: A global study of early reactions», PLoS ONE, vol. 20, n.o 2. 2025. doi: 10.1371/journal.pone.0315011.
35. N. Saif et al., «Enabling MCQ-based assessments formulation for management science lecturers: Technology readiness acceptance model validation through Chat GPT», Educational Technology and Society, vol. 28, n.o 1. pp. 319-334, 2025. doi: 10.30191/ETS.202501_28(1).TP06.
36. M. Dimeli y A. Kostas, «The Role of ChatGPT in Education: Applications, Challenges: Insights From a Systematic Review», Journal of Information Technology Education: Research, vol. 24, pp. 1-30, 2025, doi: 10.28945/5422.

37. C. A. Velandia-Rodríguez, A. Chiappe, y A. V. Sagredo, «From Uniformity to Uniqueness: Personalized Learning Through Artificial Intelligence», Journal of Social Studies Education Research, vol. 16, n.o 2, pp. 169-196, 2025.
38. I. C. Suazo-Galdamés y A. M. Chaple-Gil, «Impact of Intelligent Systems and AI Automation on Operational Efficiency and User Satisfaction in Higher Education», Ingenierie des Systemes d'Information, vol. 30, n.o 4, pp. 1057-1066, 2025, doi: 10.18280/isi.300421.
39. A.-B. Ahmed, B. D. King, K. K. Hiran, M. Dadhich, y E. Malcalm, «Half a Decade of Artificial Intelligence in Education in Africa: Trends, Opportunities, Challenges and Future Directions», Journal of Engineering Education Transformations, vol. 38, n.o 3, pp. 81-100, 2025, doi: 10.16920/jeet/2024/v38i3/24246.
40. G. F. Marchena Sekli, A. Godo, y J. C. Véliz, «GENERATIVE AI SOLUTIONS FOR FACULTY AND STUDENTS: A REVIEW OF LITERATURE AND ROADMAP FOR FUTURE RESEARCH», Journal of Information Technology Education: Research, vol. 23, 2024, doi: 10.28945/5304.
41. K. T. Chong, N. Ibrahim, S. H. Huspi, W. M. N. Wan Kadir, y M. A. Isa, «A SYSTEMATIC REVIEW OF MACHINE LEARNING TECHNIQUES FOR PREDICTING STUDENT ENGAGEMENT IN HIGHER EDUCATION ONLINE LEARNING», Journal of Information Technology Education: Research, vol. 24, 2025, doi: 10.28945/5456.
42. D. D. Mong y H. P. Thanh, «Relationship between artificial intelligence and legal education: A bibliometric analysis», Knowledge and Performance Management, vol. 8, n.o 2. pp. 13-27, 2024. doi: 10.21511/kpm.08(2).2024.02.
43. F. Y. J. Easouh, T. E. Oweis, y H. A. Makahleh, «A Bibliometric Lens on the Future: How AI continues to transform education institutions», Human Systems Management, vol. 43, n.o 6. pp. 825-844, 2024. doi: 10.3233/HSM-240005.
44. K. A. Albinali, N. A. Iahad, y A. F. Yusof, «Examining the Expansion and Collaborative Patterns of Artificial Intelligence in Education: A Bibliometric Study», International Journal of Computing and Digital Systems, vol. 15, n.o 1. pp. 1823-1837, 2024. doi: 10.12785/ijcds/1501128.
45. J. Kim, K. Merrill, K. Xu, y D. D. Sellnow, «I Like My Relational Machine Teacher: An AI Instructor's Communication Styles and Social Presence in Online Education», International Journal of Human-Computer Interaction, vol. 37, n.o 18. pp. 1760-1770, 2021. doi: 10.1080/10447318.2021.1908671.
46. F. Ouyang, M. Guo, N. Zhang, X. Bai, y P. Jiao, «Comparing the Effects of Instructor Manual Feedback and ChatGPT Intelligent Feedback on Collaborative Programming in China's Higher Education», IEEE Transactions on Learning Technologies, vol. 17. pp. 2227-2239, 2024. doi: 10.1109/TLT.2024.3486749.
47. M.-R. A. Chen, G.-J. Hwang, y Y.-Y. Chang, «A reflective thinking-promoting approach to enhancing graduate students' flipped learning engagement, participation behaviors, reflective thinking and project learning outcomes», British Journal of Educational Technology, vol. 50, n.o 5. pp. 2288-2307, 2019. doi: 10.1111/bjet.12823.
48. H. B. Essel, D. Vlachopoulos, H. Nunoo-Mensah, y J. O. Amankwa, «Exploring the impact of VoiceBots on multimedia programming education among Ghanaian university students»,

British Journal of Educational Technology, vol. 56, n.o 1. pp. 276-295, 2025. doi: 10.1111/bjet.13504.
49. S. Karkoulian, N. Sayegh, y N. Sayegh, «ChatGPT Unveiled: Understanding Perceptions of Academic Integrity in Higher Education - A Qualitative Approach», Journal of Academic Ethics. 2024. doi: 10.1007/s10805-024-09543-6.
50. N. Al-Qaysi, M. Al-Emran, M. A. Al-Sharafi, M. Iranmanesh, A. Ahmad, y M. A. Mahmoud, «Determinants of ChatGPT Use and its Impact on Learning Performance: An Integrated Model of BRT and TPB», International Journal of Human-Computer Interaction, vol. 41, n.o 9. pp. 5462-5474, 2025. doi: 10.1080/10447318.2024.2361210.
51. T. Maqbool et al., «Future pharmacy practitioners' insights towards integration of artificial intelligence in healthcare education: Preliminary findings from Karachi, Pakistan», PLoS ONE, vol. 20, n.o 2 February. 2025. doi: 10.1371/journal.pone.0314045.
52. O. Boubker, «From chatting to self-educating: Can AI tools boost student learning outcomes?», Expert Systems with Applications, vol. 238. 2024. doi: 10.1016/j.eswa.2023.121820.
53. T. Rasul et al., «Enhancing academic integrity among students in GenAI Era:A holistic framework», International Journal of Management Education, vol. 22, n.o 3. 2024. doi: 10.1016/j.ijme.2024.101041.
54. B. N. M. Alnasib y N. S. Alharbi, «Challenges and Motivation: Assessing Gemini's Impact on Undergraduate EFL Students in Classroom Settings», World Journal of English Language, vol. 14, n.o 5. pp. 501-514, 2024. doi: 10.5430/wjel.v14n5p501.
55. D.-L. Chen, K. Aaltonen, H. Lampela, y J. Kujala, «The Design and Implementation of an Educational Chatbot with Personalized Adaptive Learning Features for Project Management Training», Technology, Knowledge and Learning, vol. 30, n.o 2. pp. 1047-1072, 2025. doi: 10.1007/s10758-024-09807-5.
56. B. Kayalı, M. Yavuz, Ş. Balat, y M. Çalışan, «Investigation of student experiences with ChatGPT-supported online learning applications in higher education», Australasian Journal of Educational Technology, vol. 39, n.o 5. pp. 20-39, 2023. doi: 10.14742/ajet.8915.
57. A. M. Elsayed, A. Kholikov, I. Abdullayeva, M. Al-Farouni, y M. R. Wodajo, «Teacher support in AI-assisted exams: an experimental study to inspect the effects on demotivation, anxiety management in exams, L2 learning experience, and academic success», Language Testing in Asia, vol. 14, n.o 1. 2024. doi: 10.1186/s40468-024-00328-7.
58. A. A. F. Alzubi, M. Nazim, y N. Alyami, «Do AI-generative tools kill or nurture creativity in EFL teaching and learning?», Education and Information Technologies. 2025. doi: 10.1007/s10639-025-13409-8.
59. A. Fošner y B. Aver, «AI chatbots in higher education: Students' beliefs and concerns», Sustainable Futures, vol. 9. 2025. doi: 10.1016/j.sftr.2025.100734.
60. S. K. Howorth, M. T. Marino, S. Flanagan, M. J. Cuba, y C. Lemke, «Integrating emerging technologies to enhance special education teacher preparation», Journal of Research in Innovative Teaching and Learning. 2024. doi: 10.1108/JRIT-08-2024-0208.

61. X. Chu et al., «Enhancing the flipped classroom model with generative AI and Metaverse technologies: insights from lag sequential and epistemic network analysis», Educational Technology Research and Development. 2025. doi: 10.1007/s11423-025-10457-2.
62. M. Fawaz, W. El-Malti, S. M. Alreshidi, y E. Kavuran, «Exploring Health Sciences Students' Perspectives on Using Generative Artificial Intelligence in Higher Education: A Qualitative Study», Nursing and Health Sciences, vol. 27, n.o 1. 2025. doi: 10.1111/nhs.70030.
63. S. C. Figueiredo, «Rhetoric in the metaverse», Convergence, vol. 29, n.o 1. pp. 81-96, 2023. doi: 10.1177/13548565221138399.
64. F. Aljabr, B. Zakarneh, N. Annamalai, y N. Al Said, «Integrating AI: Challenges and Opportunities in Teaching English Writing Skills», World Journal of English Language, vol. 15, n.o 5. pp. 371-382, 2025. doi: 10.5430/wjel.v15n5p371.
65. A. Abulibdeh, E. Zaidan, y R. Abulibdeh, «Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions», Journal of Cleaner Production, vol. 437. 2024. doi: 10.1016/j.jclepro.2023.140527.
66. A. M. Al-Zahrani, «Exploring the Impact of Artificial Intelligence Chatbots on Human Connection and Emotional Support Among Higher Education Students», SAGE Open, vol. 15, n.o 2. 2025. doi: 10.1177/21582440251340615.