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CHALLENGES OF EDTECH IMPLEMENTATION IN LOW- AND MIDDLE-INCOME COUNTRIES: A BIBLIOMETRIC APPROACH

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***ABSTRACT*:**

The deployment of educational technologies (EdTech) in low- and middle-income countries constitutes one of the most significant contemporary challenges in global educational transformation. Despite growing recognition of its potential to democratize access to knowledge, implementation processes face deeply rooted structural, cultural, and technological limitations. This study seeks to answer the question: Does network analysis of terms allow the identification of challenges in EdTech implementation in low- and middle-income countries? Through a bibliometric co-occurrence network analysis of 1,191 conceptual terms defined by 548 authors, the results reveal four clusters: Cluster 1: Technology acceptance models and individual factors in EdTech adoption; Cluster 2: Health education and structural challenges in EdTech implementation within clinical and healthcare contexts; Cluster 3: Educational innovation, digital literacy, and technological planning in developing countries; and Cluster 4: Gamification, assessment, and competency development in emerging digital educational environments. These findings create new research gaps that require further exploration using advanced techniques such as factor analysis and structural equation modeling to transform the clusters into conceptual constructs

***Keywords**: EdTech, low- and middle-income countries, bibliometrics, Python*

INTRODUCTION

The adoption of educational technologies (EdTech) has emerged as a strategic pillar in global educational transformation processes. These tools hold the promise of democratizing access to knowledge, narrowing learning gaps, and fostering innovative approaches to teaching and assessment aligned with the challenges of the 21st century. However, in low- and middle-income countries (LMICs), the implementation of EdTech faces a range of complex and multidimensional obstacles, rooted in both structural limitations and deeply embedded sociocultural and pedagogical factors [1], [2].

In contrast to contexts with high technological availability, LMICs must contend with profoundly unequal starting conditions. Limited connectivity, lack of digital infrastructure, low household purchasing power, and deficiencies within the educational system converge as structural barriers that hinder the effective deployment of educational technologies [3], [4]. Moreover, the increasing reliance on external platforms often developed without consideration for the cultural or linguistic contexts of the regions in which they are implemented undermines both their effectiveness and their acceptance by the educational community [5], [6].

On the other hand, human and cultural factors play a critical role. Resistance among some educators to adopt new digital methodologies whether due to insufficient training or fear of losing control over the educational process constitutes a significant barrier [7], [8]. This is further compounded by the lack of comprehensive public policies that ensure the development of digital competencies, provide technical support, and promote continuous evaluation of the implemented programs.

In many cases, the adoption of EdTech in LMICs has been driven by isolated initiatives, lacking coordination among educational, health, and social stakeholders, which hinders both sustainability and scalability. The pressure

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to digitalize educational processes particularly during and after the COVID-19 pandemic accelerated the implementation of solutions that were not always appropriate or effective in vulnerable settings [2]. As a result, there has been a noticeable increase in fragmented interventions, with a greater emphasis on technological deployment than on actual educational outcomes [9].

Within this framework, the present bibliometric study analyzes a substantial body of recent publications in order to identify the main thematic clusters that shape the challenges of EdTech implementation in LMICs. Through a co-occurrence analysis of conceptual terms defined by various authors, four critical problem areas are identified: (1) digital divides and limited infrastructure, (2) cultural resistance and pedagogical challenges, (3) lack of contextualization of platforms and content, and (4) limited evaluation of impact and sustainability. Addressing these issues is not only essential to ensuring the right to quality education, but also fundamental for advancing toward a more equitable, sustainable, and technologically inclusive form of development.

Digital Divides and Limited Infrastructure

One of the most evident structural challenges in the implementation of educational technologies in LMICs is the persistent digital divide. This manifests on multiple levels: from unequal access to connectivity and devices to the lack of maintenance and technical support. The reviewed literature highlights how inadequate technological infrastructure particularly in rural areas hinders the functioning of educational platforms, disrupts virtual classes, and restricts student participation [10].

In many contexts, the limited availability of electricity or internet renders technology an intermittent resource, making its systematic integration into instructional planning difficult. For example, studies conducted in rural school settings report that only a fraction of educational centers have functional equipment, and that students often have to share devices among multiple household members [11].

Moreover, the cost of accessing technologies such as mobile devices, computers, and data plans represents a significant barrier for low-income households, further exacerbating educational inequality. In this context, the ideal of equitable digital education is undermined by structural conditions that demand not only investment in infrastructure, but also the implementation of affordable and sustainable connectivity policies [12], [2].

Cultural Resistance and Pedagogical Challenges

Beyond technological barriers, there are cultural, attitudinal, and pedagogical obstacles that hinder the effective adoption of EdTech in LMICs. Numerous studies emphasize that many educators particularly those with traditional training exhibit either active or passive resistance to the integration of digital tools in the classroom [7]. This attitude is influenced by a lack of confidence in technology, limited training, or the perception that digital methods are incompatible with established pedagogical frameworks.

Likewise, families and communities play an ambivalent role: while some view technology as an opportunity for progress, others perceive it as a source of distraction, risk, or cultural identity loss particularly when digital content is not aligned with their values [5].

On the other hand, the active, student-centered methodologies promoted by many EdTech platforms require a paradigm shift in teaching that is not always understood or supported. The absence of a pedagogical digital culture, combined with a lack of institutional support, limits the transformative potential of these technologies [9], [13].

Lack of Contextualization of Platforms and Content

One of the most frequently cited issues in the literature is the limited local adaptation of EdTech solutions implemented in LMICs. Many of these platforms have been designed in high-income countries and superficially translated, without taking into account the cultural, linguistic, or curricular characteristics of the regions where they are applied [5], [6]. This cultural disconnect can lead to student disengagement and teacher resistance, as neither group sees themselves reflected in the content or in the proposed learning dynamics.

Moreover, rural and intercultural contexts require materials that respect and promote cultural diversity. However, most available digital resources fail to incorporate local elements, which reduces community ownership and limits the pedagogical potential of the platforms [14].

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In addition, the lack of co-creation among developers, educators, and educational communities hinders the development of truly inclusive and context-sensitive technological solutions. The literature consistently emphasizes that effective EdTech implementation requires participatory planning grounded in real needs assessments rather than standardized models [3].

Limited Evaluation of Impact and Sustainability

A fundamental challenge identified in most studies is the absence of robust monitoring and evaluation mechanisms to assess the real impact of educational technologies implemented in PIBM [13]. Many EdTech interventions are presented as innovative solutions, yet they lack solid empirical evidence demonstrating their effectiveness in terms of learning improvement, gap reduction, or school retention.

Moreover, evaluation approaches often focus on usage indicators such as the number of users or time spent online without considering the quality of interactions, the relevance of the content, or the long-term pedagogical effects [12]. This lack of in-depth evaluation hinders the identification of best practices, the correction of shortcomings, and the scaling of successful projects.

It has also been observed that many programs lack financial sustainability, as they depend on external cooperation funds or one-time donations, without a continuity model. As a result, once funding ends, platforms become obsolete or fall into disuse, and the initial effort is lost [11], [15].

Finally, the literature underscores the need to develop digital educational governance models in which public, private, and community stakeholders work collaboratively in the planning, implementation, and evaluation of sustainable and inclusive educational technologies [16].

Applications of the PRISMA Methodology in the Field of EdTech

The PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) has become a key approach for the systematization of knowledge in the field of educational technologies (EdTech), particularly in contexts marked by accelerated digital transformation. In recent literature, PRISMA has been applied to identify thematic patterns, rigorously evaluate the methodological quality of studies, and establish inclusion and exclusion criteria that allow for an objective and reproducible analysis of research on EdTech in low- and middle-income countries [17].

Its use has facilitated the identification of critical thematic areas, such as digital accessibility, technological literacy, the impact of immersive platforms, and teacher training in virtual environments [18]. Thanks to this methodology, researchers can synthesize scattered evidence and construct analytical frameworks that reveal not only progress, but also gaps and contradictions in the implementation of technological solutions in education [19]. Moreover, the PRISMA approach has made it possible to highlight the diversity of methodological approaches used in EdTech research, ranging from experimental studies to qualitative inquiries and public policy analyses. This is particularly valuable for developing countries, where digital educational interventions must be adapted to fragile infrastructure conditions and diverse sociocultural realities [20], [21].

Applications of Bibliometrics in EdTech

The use of bibliometrics in the field of educational technologies (EdTech) has enabled the precise mapping of the scientific and thematic development of an area in constant transformation. Through co-occurrence network analysis, country-level production, institutional collaboration, and thematic evolution, bibliometric studies have provided a solid empirical foundation for understanding the research dynamics surrounding EdTech and its multiple applications in global educational contexts [22, p. 1], [23], [24].

One of the main advantages of bibliometrics in this field is its ability to identify emerging trends. Several studies have highlighted the growth of areas such as gamification-based learning, the use of artificial intelligence for personalized education, adaptive assessment, and the integration of immersive platforms all driven by the accelerated digitalization of educational processes [25], [26]. Through the analysis of keywords and thematic clusters, researchers have been able to group scientific production into categories such as “digital accessibility,” “teacher competencies,” “interactive platforms,” and “inclusive online education” [27, pp. 2010–2024].

In addition, bibliometrics has been used to evaluate the scientific productivity of regions and countries, making it possible to highlight the concentration of knowledge in high-income countries and the relative scarcity of research

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output from developing regions [28]. This asymmetry has been documented as a structural factor that limits the global representativeness of EdTech approaches, highlighting the need to promote more inclusive editorial policies and interregional collaborations [29].

At the methodological level, bibliometric research in EdTech has employed tools such as VOSviewer, Bibliometrix, and CiteSpace, which enable the generation of co-occurrence maps, international collaboration networks, and longitudinal analyses of keywords [30]. These tools have also facilitated the evaluation of the most impactful journals, the most frequently cited authors, and the most active institutions in the field, providing researchers with a clear overview of where and how the most influential knowledge is being produced [31].

Another important contribution of bibliometrics has been the identification of research gaps. Through thematic frequency analysis, it has been shown that critical subtopics such as the use of EdTech in populations with disabilities, intercultural approaches, and digital gender equity remain underexplored compared to more established areas like STEM education and digital teacher training [32].

Finally, some studies have used bibliometrics to link EdTech with the Sustainable Development Goals (SDGs), showing how digital technologies can contribute, for instance, to improving the quality of education (SDG 4) and reducing inequalities (SDG 10), while also warning of the risk of exacerbating existing gaps if the structural conditions affecting their implementation in low-resource countries are not properly addressed [33].

In summary, bibliometrics has become an indispensable methodology for understanding, evaluating, and projecting the impact of EdTech in contemporary education. Its application enables the articulation of knowledge, the identification of priority research areas, and the provision of key evidence for designing more equitable, inclusive, and data-driven public education policies.

Interquartile Level in Scientific Publications and Its Relationship with EdTech

In bibliometric studies applied to the field of educational technologies (EdTech), the analysis of interquartile level has become a key tool for evaluating the visibility, quality, and impact projection of scientific publications. The interquartile level, which classifies scientific journals indexed in Scopus or Web of Science into quartiles (Q1 to Q4), enables the ranking of sources based on their impact as measured by citation metrics, and is commonly used to identify the most influential dissemination channels within a given field of study [34].

In the case of EdTech, studies have shown that a significant portion of the scientific output is concentrated in journals ranked in Q1 and Q2, reflecting the consolidation of this field as a line of research with high international relevance [35]. This prominent presence in higher quartiles also highlights the interest of journals in education, computer science, and technology in topics such as artificial intelligence applied to teaching, immersive learning platforms, gamification, and the development of teachers' digital competencies.

However, it has also been observed that placement in higher quartiles does not necessarily guarantee the inclusion of diverse or contextually relevant perspectives. In particular, studies analyzing EdTech implementations in low- and middle-income countries tend to be underrepresented in Q1 journals, raising questions about editorial or linguistic barriers that hinder their publication in high-impact outlets [36]. This situation may lead to thematic concentration, where the most visible research focuses on privileged settings, while studies addressing digital inequality, inclusion, and intercultural approaches are relegated to the background.

Another important finding concerns the relationship between journal quartile and the type of EdTech being investigated. Studies focusing on emerging platforms, educational big data, or machine learning tend to be more frequently published in high-quartile journals, whereas those centered on basic digital literacy, rural access, or low-cost technologies are more commonly found in mid- or lower-quartile publications [37]. This suggests an implicit hierarchy of topics based on their degree of technological innovation, which reduces the visibility of approaches that although fundamental to educational equity do not always align with the priorities of the most prestigious publications.

Therefore, this document aims to address the following research question: Can term co-occurrence network analysis be used to identify the challenges of EdTech implementation in low- and middle-income countries? The following hypothesis is proposed accordingly:

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H1: There are clearly differentiated thematic clusters within the term co-occurrence network that reflect the contextual challenges such as infrastructure, teacher training, and digital access in the adoption of EdTech in low- and middle-income countries.

The growing adoption of educational technologies (EdTech) in low- and middle-income countries (LMICs) has generated a substantial body of scientific literature focused on contextual challenges, ranging from infrastructural limitations to insufficient teacher training and digital access gaps. This phenomenon can be effectively analyzed through advanced bibliometric methods particularly term co-occurrence analysis which enables the identification of semantic and conceptual patterns in recent academic literature.

The hypothesis is supported by the fact that network maps generated through co-occurrence term analysis often reveal thematic groupings or clusters that encapsulate areas of concern or development. In the case of EdTech in developing contexts, it is expected that these clusters will reflect categories such as: (i) technical and connectivity limitations, (ii) barriers to teacher training for the pedagogical use of technology, and (iii) sociocultural conditions that hinder the equitable adoption of digital platforms. The identification of these thematic nuclei not only validates the existence of structural and operational challenges, but also informs decision-making regarding public policies and technological implementation strategies tailored to local contexts.

Additionally, co-occurrence analyses in this field often employ metrics such as centrality, modularity, and semantic density, which enhance the ability to detect robust thematic communities. These communities enable the establishment of correlations between recurrent concepts such as “digital divide,” “teacher training,” “ICT infrastructure,” and “policy implementation” all of which are essential for understanding the complexity of integrating EdTech in resource-constrained settings.

Therefore, the present hypothesis posits that the bibliometric analysis of co-occurrence networks constitutes not only a valid methodological tool, but also a means to empirically systematize the challenges of technological implementation in education across the Global South. Confirming this hypothesis would validate the use of scientometric tools to support strategic interventions in the educational domain.

METODOLOGÍA

Document Selection

The document selection process followed the recommendations of the PRISMA methodology (see Figure 1). Scopus and Web of Science were selected as the primary databases due to their high reputation and rigorous publication standards (see Table 1).

Figure 1. Flow diagram PRISMA

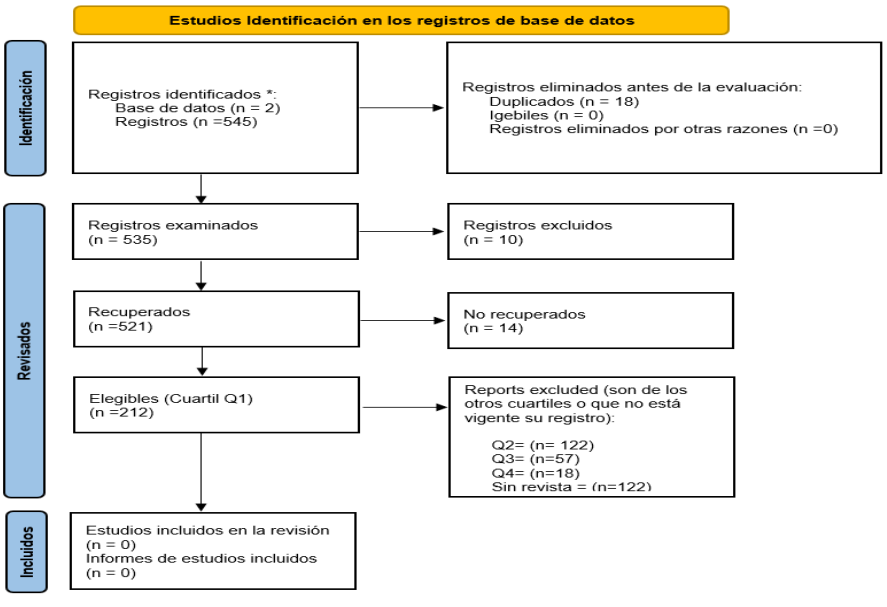

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Table 1. Search equation

Data base	Search Equation	T. Doc
Scopus	TITLE-ABS-KEY ("educational technology" OR edtech OR "digital learning" OR "technology in education" OR "ICT in education") AND TITLE-ABS-KEY ("low- and middle-income countries" OR LMIC OR "developing countries" OR "global south" OR "emerging economies") AND (LIMIT-TO (DOCTYPE , "ar"))	300
Web Of Science	"educational technology" OR edtech OR "digital learning" OR "technology in education" OR "ICT in education" (All Field) And "low- and middle-income countries" OR LMIC OR "developing countries" OR "global south" OR "emerging economies" (All Fields) Document Types: Article	245
	Total	545

Workflow Developed for Bibliometric Analysis

To design and analyze the network of conceptual terms defined by the authors, the following workflow was implemented:

1. Records from each of the selected databases were downloaded and stored in .bib format, corresponding to each source.
2. A Python script was developed to merge the .bib files and remove duplicates, resulting in a single consolidated file.
3. To select articles published in Q1-ranked journals, a custom Python script was created, yielding a total of 177 selected articles.
4. Bibliometrix version 5 (R language) was used to analyze the main bibliometric indicators.
5. VOSviewer version 1.6.20 was employed to design the network comprising 1,191 conceptual terms defined by 548 authors.
6. To extract the quartile data from the term network, the information was exported in .json format, and a Python script was developed to classify the articles according to journal quartile.

RESULTS

Analysis of Key Bibliometric Indicators

The bibliometric analysis encompassed a total of 177 documents published between 1973 and 2025, distributed across 91 scientific sources (see Figure 2), reflecting a relatively concentrated body of literature. However, the annual growth rate of 5.83% indicates a sustained increase in academic interest in the implementation of educational technologies (EdTech) in low- and middle-income countries (LMICs).

The average age of the documents is 7.41 years (see Figure 3A), indicating that much of the relevant production is recent aligned with the expansion of digital policies, the rise of mobile connectivity, and the urgent need to address technological gaps exacerbated during and after the COVID-19 pandemic. Moreover, the average impact of the publications, measured by citations per document (11.71) (see Figure 3B), reflects moderate reception within the scientific community, further reinforcing EdTech's relevance as an emerging field of research in the context of educational equity.

Regarding thematic content, 809 Keywords Plus (ID) and 1,191 author-declared keywords (DE) were identified (see Figure 3C), indicating a broad conceptual and terminological diversity within the field. This semantic breadth supports the hypothesis that differentiated thematic clusters exist, centered on dimensions such as technological infrastructure, teacher training, and digital accessibility key elements in characterizing implementation challenges in low-resource regions.

The analysis also identified the involvement of 548 authors, 25 of whom produced single-authored documents. Scientific collaboration was notable, with an average of 3.54 co-authors per document.

Finally, a total of 4,643 bibliographic references were recorded, indicating a robust theoretical and empirical foundation in the field. This volume of references supports the feasibility of applying co-occurrence and semantic

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network analysis techniques, enabling the precise identification of the structural and contextual challenges faced in the implementation of EdTech across the Global South.

Figure 2. **Medias bibliometricas**

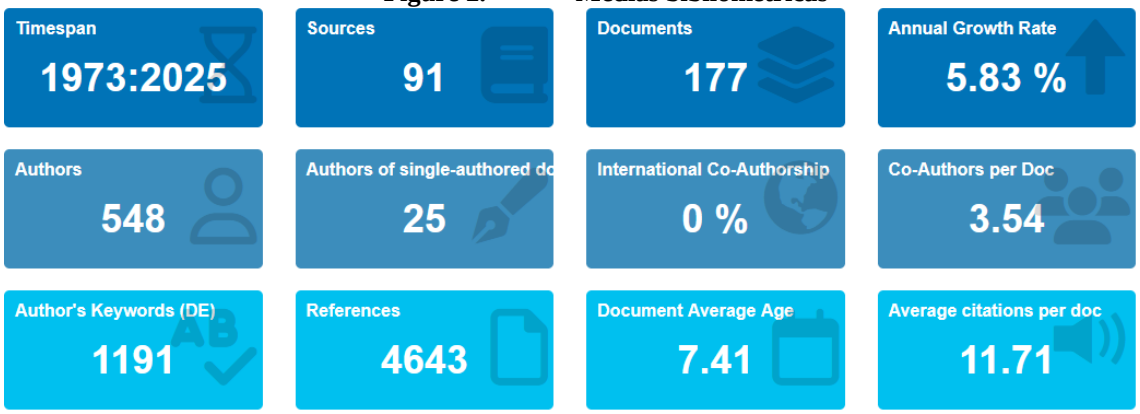
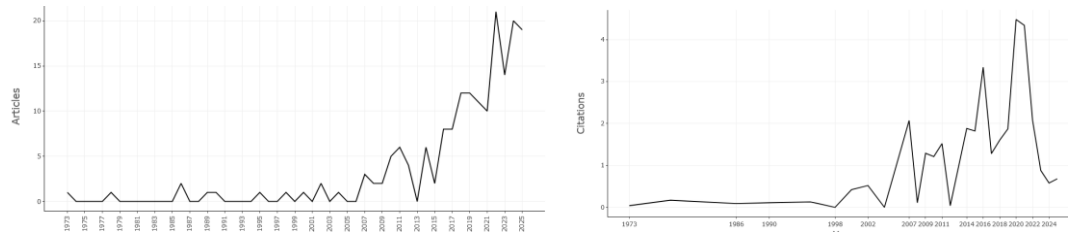
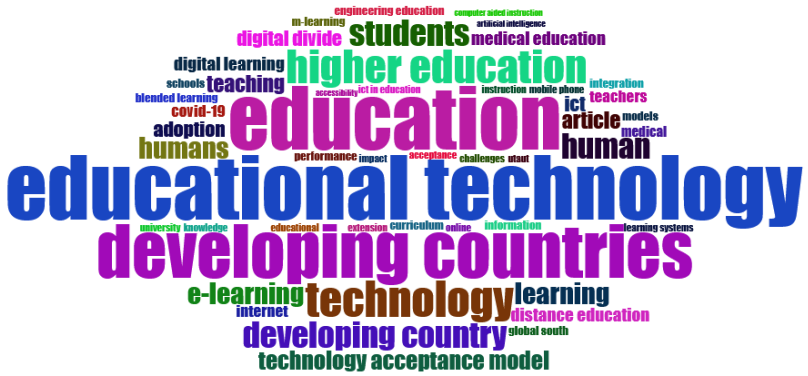


Figure 3.

A B



C



Note: A) Annual Scientific Production. B) Average Citations Per Year. C) WordCloud

Co-occurrence Term Network

The co-occurrence term network was constructed based on 1,191 terms defined by 548 authors (see Figure 4). From this network, four clusters were identified, each concentrating a distinct group of co-occurring terms. The first cluster was labeled: *Technology Acceptance Models and Individual Factors in EdTech Adoption*. The second cluster was defined as: *Health Education and Structural Challenges in EdTech Implementation in Clinical and Healthcare Contexts*. The third cluster was named: *Educational Innovation, Digital Literacy, and Technological Planning in Developing Countries*. Finally, the fourth cluster was titled: *Gamification, Assessment, and Competency Development in Emerging Digital Learning Environments*. The following section provides a literature-based review and definition of each of these clusters.

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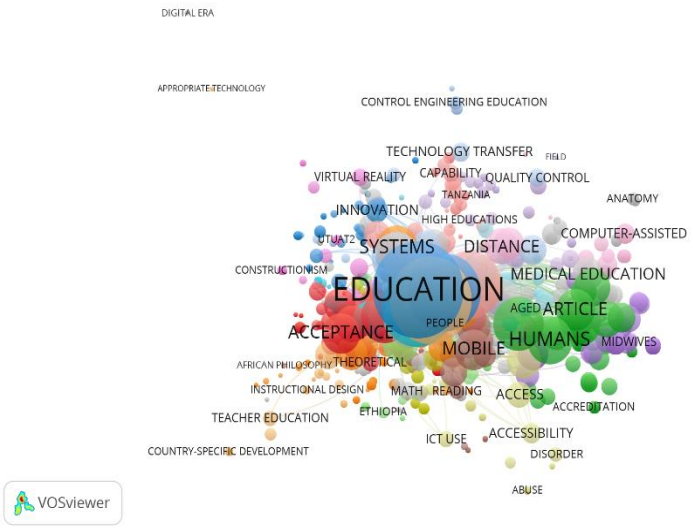
Figure 4. Red de co-occurrencia de terminos



Cluster 1: Technology Acceptance Models and Individual Factors in EdTech Adoption
Collectively, the terms reflect an analytical focus on understanding user behavior in relation to EdTech adoption a key line of research for addressing implementation challenges in resource-limited settings (see Figure 5).

Bibliometric analysis reveals a first cluster centered on technology acceptance models and individual factors influencing the adoption of educational technologies (EdTech), particularly in the context of low- and middle-income countries. This cluster encompasses studies that, although they do not always explicitly reference models such as TAM (Technology Acceptance Model) or UTAUT (Unified Theory of Acceptance and Use of Technology), do explore key elements such as attitudes toward platform usage, personal motivation, digital literacy, access to resources, and the sociocultural conditions that mediate the relationship between users and technology.

For example, digital competencies and technological literacy are highlighted as key determinants in the adoption of EdTech, particularly in contexts where access to devices or connectivity is limited. These individual factors are closely linked to the potential for technological appropriation by teachers and students within ICT-mediated teaching and learning processes. This framing offers a perspective on the phenomenon grounded in personal and cultural skills necessary for the effective integration of educational technology [14].

Similarly, some studies emphasize how generational differences, levels of prior education, and cultural beliefs regarding technology influence either the acceptance or resistance to using digital platforms. In this regard, user experience becomes a central node within the cluster, as factors such as user-friendly interfaces, perceived usefulness, and trust in the system critically shape the intention to use EdTech solutions [38].

Another aspect identified within this cluster is the role of teachers as either facilitators or barriers in the adoption of EdTech. Teachers' attitudes toward innovation, their technical training, and their openness to change are personal variables that directly impact the implementation of technologies in the classroom, as demonstrated by studies on pedagogical integration in rural or marginalized areas [39].

Finally, several studies examine the affective dimension of technology-enhanced learning, emphasizing that intrinsic motivation, perceived self-efficacy, and a sense of autonomy influence the sustained use of EdTech. These findings underscore the importance of user-centered approaches that integrate psychological and sociocultural factors into the design and dissemination of technological solutions for education in vulnerable contexts [40].

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Cluster 2: Health Education and Structural Challenges in EdTech Implementation in Clinical and Healthcare Contexts

This thematic group reflects a specific focus on how the challenges of EdTech implementation manifest uniquely in the context of medical education, teaching hospitals, and healthcare systems in developing countries. The barriers in this cluster are not only technological, but also organizational, curricular, and related to the shortage of qualified personnel calling for comprehensive solutions to enable the effective adoption of educational technologies in the health sector (see Figure 5).

Cluster 2 identified in the bibliometric analysis focuses on the integration of educational technologies (EdTech) into training processes related to health, and on the multiple structural challenges that condition their adoption in clinical and healthcare environments. The studies grouped within this cluster reflect a growing concern with enhancing the digital competencies of healthcare personnel, promoting health literacy among the population, and strengthening the responsiveness of health systems through the use of educational technological resources.

A recurring line of research involves the use of digital platforms for training healthcare professionals in resource-limited settings. These solutions which range from mobile applications to virtual clinical simulators enable real-time knowledge updates with spatial flexibility, effectively breaking down geographic and informational access barriers [5]. In particular, tele-education has emerged as a valuable strategy for sustaining continuous training in emergency contexts, as was the case during the COVID-19 pandemic [41].

However, the implementation of EdTech in these settings faces serious structural limitations. The lack of digital infrastructure such as stable connectivity, adequate equipment, and technical support is one of the main barriers to its sustainable adoption [42]. These challenges are compounded by institutional difficulties, such as the absence of regulatory frameworks that support the integration of digital technologies into medical science curricula, as well as the limited digital training of instructors themselves [43].

Additionally, cultural tensions regarding the use of technological tools in healthcare are evident. Some communities or healthcare institutions express resistance to change, particularly when technologies are perceived as dehumanizing clinical care or imposing educational models that are disconnected from local realities [44]. In this regard, the cultural and linguistic relevance of digital content becomes crucial for effective implementation, and several studies emphasize the need to involve community stakeholders in the design of contextually appropriate educational resources [41].

A significant gap is also identified between the availability of technologies and their effective utilization. In many rural or peripheral contexts, even when technological devices are available, their use is limited due to insufficient staff training resulting in a phenomenon of "educational underutilization" [45]. This highlights that the challenges are not exclusively technical, but also social and organizational in nature.

Finally, the studies in this cluster emphasize the need to establish monitoring and evaluation systems to assess the impact of EdTech on clinical training, professional performance, and population health outcomes. Without clear indicators and feedback mechanisms, technology adoption risks becoming a superficial solution with no real long-term effects [46].

Cluster 3: Educational Innovation, Digital Literacy, and Technological Planning in Developing Countries

This cluster represents the challenges associated with bringing innovative technologies to geographically and socially diverse contexts, where technological implementation must take into account structural limitations, digital competencies, and strategic planning. The presence of terms such as *Colombia*, *Sub-Saharan Africa*, and *developing economies* reinforces the regional and contextual focus of the analysis (see Figure 5).

Cluster 3 brings together research addressing the intersection of educational innovation, digital literacy, and technological planning in the context of developing countries. This thematic axis has gained momentum due to the growing need to transform educational systems through inclusive digital strategies tailored to the socio-technical realities of the most disadvantaged regions. The analyzed abstracts reveal a strong concern about the digital divide as a structural factor that limits equitable access to education and hinders the effective implementation of EdTech [47].

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Several studies emphasize that digital literacy should not be reduced to the technical ability to operate devices, but rather understood as a set of critical, communicative, and cognitive competencies that enable students and teachers to actively participate in digital environments. This critical perspective on access to technology becomes a central axis for pedagogical innovation, especially in regions where technological inequality persists in a structural manner [8].

The cluster also reveals that in many developing countries, technological implementation plans often lack a long-term vision. Planning is frequently reactive driven by emergencies or temporary funding without adequately considering factors such as sustainability, ongoing teacher training, or the infrastructure required to support digital learning environments [48]. This has resulted in fragmented public policies and weak coordination between the education and technology sectors, which is reflected in uneven outcomes in the effective adoption of digital platforms [49].

Another key finding relates to the role of educational innovation as an adaptive response to changing contexts. The initiatives analyzed propose flexible and hybrid models that combine online resources, context-specific teacher training, and content tailored to local realities [50]. These strategies help overcome structural limitations and even strengthen educational resilience in the face of crises such as pandemics, forced displacement, or armed conflict.

In this regard, technological planning in education emerges not only as a tool for modernizing teaching, but also for democratizing knowledge and addressing long-standing gaps in exclusion. The most robust proposals within the cluster incorporate collaborative, cross-sectoral, and participatory approaches that enable the co-construction of meaningful technological solutions for educational communities [43].

Finally, an emerging trend is the linkage of digital literacy with other components of sustainable development, such as gender equity, youth employability, and digital citizenship. These connections reveal that educational innovation must be approached as part of a comprehensive ecosystem that integrates technology, pedagogy, and social justice in developing countries [51].

Cluster 4: Gamification, Assessment, and Competency Development in Emerging Digital Learning Environments

The terms in this cluster reflect an interdisciplinary approach that explores how educational technologies particularly those based on games and mobile applications can influence competency development, student motivation, and professional preparedness in contexts where social and technological conditions remain limited. At the same time, the cluster highlights challenges related to objective assessment, playful implementation, and the responsible use of adaptive intelligent systems (see Figure 5).

The fourth cluster identified in the bibliometric analysis brings together a set of studies focused on three fundamental axes: gamification as an innovative educational strategy, the transformation of assessment processes in digital contexts, and the development of key competencies in students who engage with virtual learning environments. These studies, primarily situated in countries undergoing active educational digitalization processes, highlight how emerging technologies are reshaping traditional pedagogy and redefining the role of students within the expanded classroom [49].

Educational gamification defined as the incorporation of game elements into non-game environments has become a powerful tool for motivating students, increasing their engagement, and promoting more meaningful learning experiences. Recent studies show that the use of virtual rewards, badges, levels, progressive challenges, or personalized avatars stimulates active participation and supports sustained engagement in digital educational platforms, even in contexts characterized by initially low levels of motivation [52]. This strategy is particularly useful for overcoming the emotional distancing that often characterizes remote learning, fostering a sense of belonging and dynamism within the virtual community [53].

On the other hand, assessment processes in digital environments have undergone significant evolution. Far from being limited to traditional digitized tests, current platforms allow for the implementation of adaptive, analytical, and personalized evaluation systems capable of providing real-time feedback and tracking individual student progress. These systems not only assess cognitive performance but also enable the evaluation of soft skills such as collaboration, time management, and decision-making in simulated scenarios [43], [54]. Several studies within

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the cluster indicate that the integration of gamification and assessment strengthens student autonomy and promotes a metacognitive approach to learning [55].

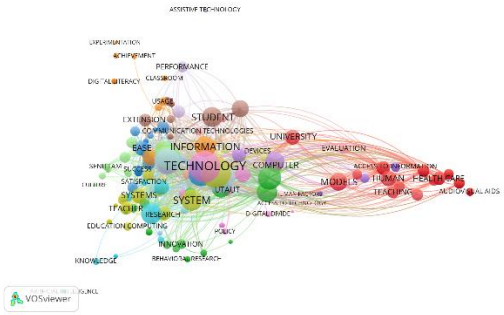
The development of transversal competencies represents the third pillar of this cluster. Emerging digital learning, environments are placing new demands on educational systems, where the transmission of knowledge alone is no longer sufficient. It has become essential to cultivate digital citizens who can adapt to changing contexts. Among the most frequently promoted competencies are digital literacy, creativity, resilience, critical thinking, problem-solving, and technology-mediated collaborative work [41]. These competencies are reinforced through active strategies and interactive environments that offer continuous challenges, tailored to each student's level and aligned with defined learning objectives [53].

It is important to note that the effectiveness of these innovations largely depends on proper pedagogical planning and teacher training. The reviewed literature emphasizes that it is not enough to incorporate technology or game-based dynamics; it is essential that these elements be integrated into a robust instructional design grounded in the principles of active, inclusive, and meaningful learning [49], [52]. Teacher training in the critical use of these tools, as well as the evaluation of their impact at the curricular, institutional, and individual levels, are necessary conditions to ensure the quality and equity of emerging digital educational processes.

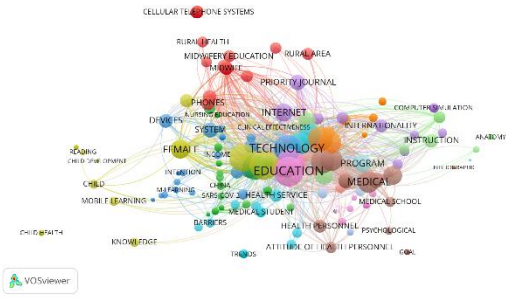
Finally, the cluster underscores that the integration of gamification, digital assessment, and competency development should not be viewed as a pedagogical trend, but rather as a structural response to the cultural and technological transformations shaping the global educational landscape. In this sense, virtual environments emerge as living laboratories of innovation spaces where data, emotions, interactions, and learning converge, demanding to be understood through a comprehensive and interdisciplinary lens.

Figure 5.

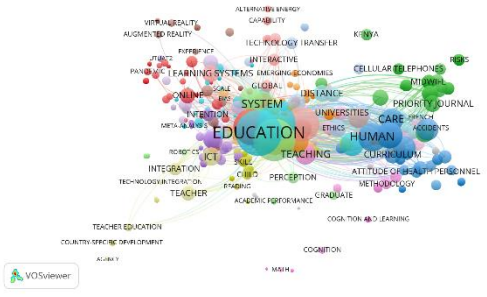
Clúster 1



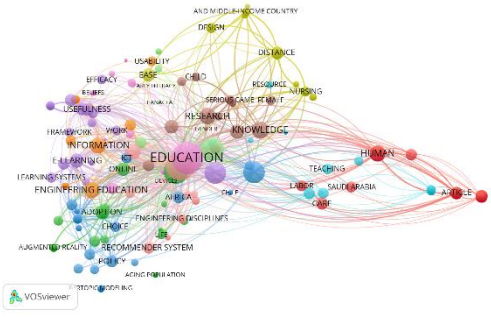
Clúster 2



Clúster 3



Clúster 4



Note: Cluster 1: Technology Acceptance Models and Individual Factors in EdTech Adoption, Cluster 2: Health Education and Structural Challenges in EdTech Implementation in Clinical and Healthcare Contexts, Cluster 3: Educational Innovation, Digital Literacy, and Technological Planning in Developing Countries, Cluster 4: Gamification, Assessment, and Competency Development in Emerging Digital Learning Environments.

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CONCLUSION

The implementation of educational technologies (EdTech) in low- and middle-income countries (LMICs) represents a complex challenge that goes beyond the purely technological and extends into structural, sociocultural, pedagogical, and governance dimensions. This bibliometric study has enabled the identification and systematization of the main challenges through the co-occurrence analysis of conceptual terms, revealing four interrelated thematic clusters that reflect both the magnitude and specificity of the issues faced in these contexts. First, digital divides and limited infrastructure remain foundational obstacles, particularly in rural or peripheral areas where connectivity, access to devices, and technological sustainability are severely compromised. Second, cultural resistance and pedagogical challenges highlight a disconnect between technological proposals and traditional educational practices, exacerbated by insufficient teacher training and limited community involvement in the design of solutions. Third, the lack of contextualization of platforms and content results in a mismatch between available digital resources and the cultural, linguistic, and curricular realities of local communities, thereby limiting both the appropriation and pedagogical effectiveness of the tools implemented. Finally, the absence of robust evaluation and sustainability models threatens the continuity and improvement of EdTech initiatives, as systematic mechanisms to monitor their impact and scalability are often lacking.

By combining PRISMA and bibliometric methodologies, this study validates the hypothesis that the challenges surrounding EdTech adoption in LMICs can be mapped through differentiated thematic clusters in co-occurrence networks, enabling the identification of semantic and conceptual patterns that guide both research and decision-making. Furthermore, bibliometrics has not only revealed knowledge gaps such as the limited representation of intercultural or gender-focused studies but also exposed the concentration of academic discourse in high-income countries, reinforcing the need for more inclusive editorial policies and South–South collaborations.

In conclusion, ensuring a fair and effective digital educational transformation in LMICs requires moving beyond fragmented interventions toward integrated models that combine infrastructure development, teacher training, cultural contextualization, and continuous evaluation. This systemic and evidence-based approach is essential for educational technologies to move from being isolated tools to becoming true catalysts for equity, inclusion, and quality education in the Global South.

REFERENCES

1. N. Jindal y S. Sahu, «Exploring the use of mobile phones by children with intellectual disabilities: experiences from Haryana, India», Disability and Rehabilitation: Assistive Technology, vol. 19, n.o 1. pp. 247-253, 2024. doi: 10.1080/17483107.2022.2079008.
2. S. Ngalomba, F. Mkwananzi, y P. Mukwambo, «Internationalization at a distance via virtual mobility in the Global South: Advances and challenges», British Journal of Educational Technology, vol. 56, n.o 2. pp. 927-946, 2025. doi: 10.1111/bjet.13557.
3. V. T. T. Nguyen y H.-L. Chen, «Examining impacts of information system success and perceived stress on students' self-regulated learning mediated by intrinsic motivation in online learning environments: second-order structural equation modelling analyses», EDUCATION AND INFORMATION TECHNOLOGIES, vol. 28, n.o 10. SPRINGER, ONE NEW YORK PLAZA, SUITE 4600, NEW YORK, NY, UNITED STATES, pp. 12945-12968, octubre de 2023. doi: 10.1007/s10639-023-11685-w.
4. É. Berde, S. T. Mengesha, B. A. Mola, y S. Remsei, «Massive Open Online Courses (MOOCs) for Ethiopian Educators: Evaluating MOOCs as a global development tool», Research in Globalization, vol. 9. 2024. doi: 10.1016/j.resglo.2024.100263.
5. H. Cheng, «Linking personal initiative and family help as well as social support: a case study of learning challenges and solutions for older adults in rural China during the COVID-19 pandemic», Frontiers in Public Health, vol. 12. 2024. doi: 10.3389/fpubh.2024.1384527.

DOI: 10.46121/pspc.53.3.7

6. S. P. Han y B. Kumwenda, «Bridging the digital divide: Promoting equal access to online learning for health professions in an unequal world», Medical Education, vol. 59, n.o 1. pp. 56-64, 2025. doi: 10.1111/medu.15455.
7. B. Ly, B. Doeur, y S. nat, «Key factors influencing digital learning adoption among cambodian university students: An integrated theoretical approach», Computers in Human Behavior Reports, vol. 15. 2024. doi: 10.1016/j.chbr.2024.100460.
8. A. Ayesha, «Practices of and for autonomy in a Pakistani blended learning environment», Innovations in Education and Teaching International, vol. 62, n.o 2. pp. 401-415, 2025. doi: 10.1080/14703297.2024.2344686.
9. O. Balli y E. Singla, «Dimensions of scale: Connected Learning Initiative (CLIx)—a case study of educational technology initiative in India», Educational Technology Research and Development, vol. 72, n.o 4. pp. 2213-2235, 2024. doi: 10.1007/s11423-024-10372-y.
10. A. Abdelghaffar y L. Eid, «A critical look at equity in international doctoral education at a distance: A duo's journey», BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY, vol. 56, n.o 2. WILEY, 111 RIVER ST, HOBOKEN 07030-5774, NJ USA, pp. 834-851, marzo de 2025. doi: 10.1111/bjet.13566.
11. F. Hamad, A. Shehata, y N. Al Hosni, «Predictors of blended learning adoption in higher education institutions in Oman: theory of planned behavior», INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION, vol. 21, n.o 1. SPRINGER, ONE NEW YORK PLAZA, SUITE 4600, NEW YORK, NY, UNITED STATES, 19 de febrero de 2024. doi: 10.1186/s41239-024-00443-8.
12. M. R. M. Dangi, M. M. Saat, y S. Saad, «Teaching and learning using 21st century educational technology in accounting education: Evidence and conceptualisation of usage behaviour», Australasian Journal of Educational Technology, vol. 39, n.o 1. pp. 19-38, 2023. doi: 10.14742/ajet.6630.
13. N. Ruiz, J. Tejera, O. Sabalza, S. Soache, y G. Jassir, «Rebusque and minimal computing in rural Colombia: LibreEscuela, an OER co-creation project», Learning, Media and Technology, vol. 49, n.o 5. pp. 827-839, 2024. doi: 10.1080/17439884.2024.2387227.
14. R. S. Abdullah, F. H. Masmali, A. Alhazemi, C. W. Onn, y S. M. F. Ali Khan, «Enhancing institutional readiness: A Multi-Stakeholder approach to learning analytics policy with the SHEILA-UTAUT framework using PLS-SEM», Education and Information Technologies. 2025. doi: 10.1007/s10639-025-13647-w.
15. L. Rodrigues et al., «MathAIde: A Qualitative Study of Teachers' Perceptions of an ITS Unplugged for Underserved Regions», International Journal of Artificial Intelligence in Education, vol. 35, n.o 1. pp. 2-30, 2025. doi: 10.1007/s40593-024-00397-y.
16. E. R. Hoskin, S. D. Pinder, y T. C. Davies, «Development of BrailleBunny: a device to enhance braille learning», Disability and Rehabilitation: Assistive Technology, vol. 19, n.o 4. pp. 1610-1625, 2024. doi: 10.1080/17483107.2023.2224404.
17. M. Y. F. Jusoh, N. A. Ishak, W. A. Mustafa, N. F. M. Mohd Nasir, S. N. M. Said, y R. R. Sukardi, «Fostering Innovation in K-12 Education: A Systematic Review of the Integration of Design Thinking within Educational Technology», vol. 53, n.o 1, pp. 153-174, 2025, doi: 10.37934/araset.53.1.153174.

DOI: 10.46121/pspc.53.3.7

18. M. K. Dwivedi y N. Virmani, «Disruptive innovation of EdTech companies in emerging economy during COVID-19», vol. 18, n.o 4, pp. 388-408, 2023, doi: 10.1504/IJLT.2023.135905.
19. O. E. H. Elmahdi, A. A. S. Balla, A. H. Abdelrady, E. Osman, y A. O. A. Ahmed, «AI-Driven Vocabulary Acquisition in EFL Higher Education: Interdisciplinary Insights into Technological Innovation, Ethical Challenges, and Equitable Access», vol. 7, n.o 4, pp. 477-491, 2025, doi: 10.30564/fls.v7i4.8760.
20. M. J. Sosa-Díaz, M. C. Sierra-Daza, R. Arriazu-Muñoz, F. Llamas-Salguero, y N. Durán-Rodríguez, «"EdTech Integration Framework in Schools": Systematic Review of the Literature», vol. 7, 2022, doi: 10.3389/feduc.2022.895042.
21. C. G. Jensen, S. Otto, S. Dau, N. R. Clausen, T. Andersen, y L. B. Bertel, «A Literature Study on Experiential Collaborative e-Learning Based on ECEL Articles», 2022, pp. 128-136. [En línea]. Disponible en: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85172383035&partnerID=40&md5=f1935f9c4d5a5857b024757b1adc85da
22. N. Kerssens y J. van Dijck, «The platformization of primary education in The Netherlands», vol. 46, n.o 3. pp. 250-263, 2021. doi: 10.1080/17439884.2021.1876725.
23. V. Aaradhi y D. Chakraborty, «EdTech applications and their adoption in Indian education sector–a bibliometric analysis and systematic literature review», vol. 14, n.o 2. pp. 510-528, 2024. doi: 10.1108/HESWBL-09-2022-0192.
24. B. Cefa, F. Macgilchrist, H. Elgamal, J. Y. H. Bai, O. Zawacki-Richter, y F. S. Loglo, «Responses to the Initial Hype: ChatGPT Supporting Teaching, Learning, and Scholarship?», vol. 17, n.o 2. pp. 227-250, 2025. doi: 10.55982/openpraxis.17.2.872.
25. A. León-Garrido, J. M. Barroso-Osuna, y C. Llorente-Cejudo, «Conceptual Cartography for the Systematic Study of Music Education Based on ICT or EdTech», vol. 12, n.o 5. 2022. doi: 10.3390/soc12050136.
26. H. Sharma, «Mapping the Global EdTech Revolution during the Pandemic: From 'Determinism' to 'Solutionism'». 2022. doi: 10.1007/978-3-030-88234-1_7.
27. M. Bond, «The International Journal of Educational Technology in Higher Education: content and authorship analysis 2010–2024», vol. 21, n.o 1. 2024. doi: 10.1186/s41239-024-00492-z.
28. M. Avelar, «Mapping the digital education landscape: Stakeholders and networks of governance in Brazil», vol. 112. 2025. doi: 10.1016/j.ijedudev.2024.103192.
29. J. Kasperiuniene y F. Faiella, «Bibliometric Analysis of Virtual Reality in School and University Contexts», vol. 688 LNNS. pp. 72-92, 2023. doi: 10.1007/978-3-031-31346-2_5.
30. B. Moser-Mercer et al., «EdTech in humanitarian contexts: whose evidence base?», vol. 8. 2023. doi: 10.3389/feduc.2023.1038476.
31. S. Gupta, R. Bajaj, B. Das, J. Kaur, y N. Kapoor, «Determining students' behavioural intention towards online learning using EdTech apps applying the UTAUT model: A case study of school students during the Covid-19 pandemic». 2024. doi: 10.4324/9781003491712-5.
32. «8th International XR-Metaverse Conference, XR 2023». 2024. [En línea]. Disponible en: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85184110081&partnerID=40&md5=74e41a1d245465b196a1b45195c481a6

DOI: 10.46121/pspc.53.3.7

33. A. B. Rensfeldt y T. Hillman, «The relational powers of platforms and infrastructures played out in school: Differences and implications for teacher work». 2023. doi: 10.4324/9781003359722-9.
34. P. Izaguirre et al., «Characteristics of rheumatic patients who consult digital information sources; Características de los pacientes reumáticos que consultan fuentes de información digitales», vol. 32, n.o 1. pp. 43-48, 2025. doi: 10.1016/j.rcreu.2023.11.007.
35. B. K. Prahani, H. V. Saphira, B. Jatmiko, S. Suryanti, y T. Amelia, «The impact of emerging technology in physics over the past three decades», vol. 21, n.o 1. pp. 134-152, 2024. doi: 10.36681/tused.2024.008.
36. I. Dergaa, K. Chamari, P. Zmijewski, y H. Ben Saad, «From human writing to artificial intelligence generated text: examining the prospects and potential threats of ChatGPT in academic writing», vol. 40, n.o 2. pp. 615-622, 2023. doi: 10.5114/BIOLSPORT.2023.125623.
37. F. V. Y. Tjong et al., «The learning curve associated with the implantation of the Nanostim leadless pacemaker», vol. 53, n.o 2. pp. 239-247, 2018. doi: 10.1007/s10840-018-0438-8.
38. A. Gunasinghe, J. A. Hamid, A. Khatibi, y S. M. F. Azam, «The adequacy of UTAUT-3 in interpreting academician's adoption to e-Learning in higher education environments», Interactive Technology and Smart Education, vol. 17, n.o 1. pp. 86-106, 2020. doi: 10.1108/ITSE-05-2019-0020.
39. Y. Li, Y. Duan, Z. Fu, y P. Alford, «An empirical study on behavioural intention to reuse e-learning systems in rural China», British Journal of Educational Technology, vol. 43, n.o 6. pp. 933-948, 2012. doi: 10.1111/j.1467-8535.2011.01261.x.
40. L. C. G. Lobo y H. E. Jouval, «The use of new educational technology in the development of health manpower in latin america: Its implications in the teaching of epidemiology», International Journal of Epidemiology, vol. 2, n.o 4. pp. 359-366, 1973. doi: 10.1093/ije/2.4.359.
41. J. O. Busari, E. A. Verhagen, F. D. Muskiet, y A. J. Duits, «Implementation of a competency-based residency curriculum: Experiences from a resource-limited environment in the Caribbean», Medical Teacher, vol. 30, n.o 9-10. pp. e189-e195, 2008. doi: 10.1080/01421590802337112.
42. H. Edgcombe, C. Paton, y M. English, «Enhancing emergency care in low-income countries using mobile technology-based training tools», Archives of Disease in Childhood, vol. 101, n.o 12. pp. 1149-1152, 2016. doi: 10.1136/archdischild-2016-310875.
43. A. S. Almeneessier y A. S. BaHammam, «Sleep medicine in Saudi Arabia», Journal of Clinical Sleep Medicine, vol. 13, n.o 4. pp. 641-645, 2017. doi: 10.5664/jcsm.6566.
44. P. Gaengler et al., «1.1 Studentselection and the influenceof their clinical and academic environment on learning», European Journal of Dental Education, vol. 6, n.o SUPP.3. pp. 8-26, 2002. doi: 10.1034/j.1600-0579.6.s3.3.x.
45. E. Falk-Nilsson et al., «1.2 Cognition and learning», European Journal of Dental Education, vol. 6, n.o SUPP.3. pp. 27-32, 2002. doi: 10.1034/j.1600-0579.6.s3.4.x.
46. A. Geissbuhler, C. O. Bagayoko, y O. Ly, «The RAFT network: 5 years of distance continuing medical education and tele-consultations over the Internet in French-speaking Africa»,

DOI: 10.46121/pspc.53.3.7

International Journal of Medical Informatics, vol. 76, n.o 5-6. pp. 351-356, 2007. doi: 10.1016/j.ijmedinf.2007.01.012.

47. B. Acharya y J. Lee, «Users' perspective on the adoption of e-learning in developing countries: The case of Nepal with a conjoint-based discrete choice approach», Telematics and Informatics, vol. 35, n.o 6. pp. 1733-1743, 2018. doi: 10.1016/j.tele.2018.05.002.
48. S. Ali, Y. Hafeez, M. A. Abbas, M. Aqib, y A. Nawaz, «Enabling remote learning system for virtual personalized preferences during COVID-19 pandemic», Multimedia Tools and Applications, vol. 80, n.o 24. pp. 33329-33355, 2021. doi: 10.1007/s11042-021-11414-w.
49. P. C. Abrami, C. A. Wade, L. Lysenko, J. Marsh, y A. Gioko, «Using educational technology to develop early literacy skills in Sub-Saharan Africa», Education and Information Technologies, vol. 21, n.o 4. pp. 945-964, 2016. doi: 10.1007/s10639-014-9362-4.
50. F. Badar y J. Mason, «Recalibrating educational opportunity for underprivileged communities in Pakistan», Prospects, vol. 54, n.o 3. pp. 661-685, 2024. doi: 10.1007/s11125-024-09712-w.
51. V. Agarwal, P. Verma, y G. Ferrigno, «Education 5.0 challenges and sustainable development goals in emerging economies: A mixed-method approach», Technology in Society, vol. 81. 2025. doi: 10.1016/j.techsoc.2025.102814.
52. Z. Apostolou, N. Stellakis, y G. Koustourakis, «PRE-PRIMARY AND FIRST GRADE PRIMARY SCHOOL TEACHERS' PERCEPTIONS ON THE INTEGRATION OF PRE-PRIMARY AND FIRST GRADE PRIMARY SCHOOL CURRICULA IN GREECE», L1 EDUCATIONAL STUDIES IN LANGUAGE AND LITERATURE, vol. 20. Int Assoc Research L1 Education - ARLE, -, Hildesheim, GERMANY, 2020. doi: 10.17239/L1ESLL-2020.20.01.14.
53. S. Banerjee y A. Pan, «From Colonial Legacies to Linguistic Inclusion: A BERTopic Enhanced Bibliometric Insight Into Global South Higher Education», IEEE Access, vol. 12. pp. 117418-117435, 2024. doi: 10.1109/ACCESS.2024.3447894.
54. A. S. Blignaut, J. E. Hinostroza, C. J. Els, y M. Brun, «ICT in education policy and practice in developing countries: South Africa and Chile compared through SITES 2006», Computers and Education, vol. 55, n.o 4. pp. 1552-1563, 2010. doi: 10.1016/j.compedu.2010.06.021.
55. J. M. Amoedo, B. Blanco-Varela, y H. Campos-Romero, «Information and communication technologies and the COVID-19: from economic inequality to educational digital divide in central and South America», Information Technology for Development. 2025. doi: 10.1080/02681102.2025.2502406.

DOI: 10.46121/pspc.53.3.7