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Technological Infrastructure in Teaching-Learning Processes in Educational Institutions: A Systematic Review

Infraestructura tecnológica en los procesos de enseñanza-aprendizaje en instituciones educativas: una revisión sistemática

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Summary

The COVID-19 pandemic accelerated the adoption of virtual and hybrid teaching methods, leading to substantial changes in educational approaches. This study focused on evaluating the effect of mediating technologies on post-pandemic educational processes, emphasizing their essential role in enhancing interaction and cooperation between teachers and students. Although their relevance is evident, challenges persist in terms of access, quality, and evaluation of technological educational initiatives. To address these challenges, a comprehensive literature review was conducted, examining 26 international academic studies published in the last five years. The findings indicate that mediating technologies positively influence motivation, student retention, and self-directed learning, especially in higher education and language teaching. However, the effects vary depending on the context. It is recommended to implement a technological strategy in the classroom that enhances learning and supports holistic education, highlighting the importance of developing comprehensive programs for planning, execution, and evaluation of educational technologies before applying these findings in specific contexts like Colombia.

Keywords: Technological mediation; Teaching processes; Learning processes; Technological education; Virtual education.

Resumen

La pandemia del COVID-19 aceleró la adopción de métodos de enseñanza virtuales e híbridos, provocando cambios sustanciales en los enfoques educativos. Este estudio se centró en evaluar el efecto de las tecnologías mediadoras en los procesos educativos posteriores a la pandemia, subrayando su rol esencial en mejorar la interacción y cooperación entre docentes y estudiantes. Aunque su relevancia es evidente, persisten desafíos en cuanto al acceso, la calidad y la evaluación de las iniciativas educativas tecnológicas. Para enfrentar estos retos, se ejecutó una revisión literaria, examinando 26 estudios académicos internacionales publicados en los últimos cinco años. Los hallazgos indican que las tecnologías mediadoras influyen positivamente en la motivación, la retención de estudiantes y el aprendizaje autodirigido, especialmente en la educación superior y la enseñanza de idiomas. Sin embargo, los efectos varían según el contexto. Se recomienda una estrategia de implementación tecnológica en el aula que potencie los aprendizajes y apoye una formación integral, resaltando la importancia de desarrollar programas integrales de planificación, ejecución y evaluación de tecnologías educativas antes de aplicar estos hallazgos en contextos específicos como el colombiano.

Palabras claves: Mediación tecnológica; Procesos de enseñanza; Procesos de aprendizaje; Educación tecnológica; Educación virtual.

INTRODUCTION

The advent of COVID-19 has strongly affected traditional education and educational management (Baber, 2021), making educational centers, teachers, and students quickly adopt the use of technologies to continue their pedagogical activities in isolation and social distancing conditions (Barnes, 2020). Technological infrastructure, including devices and Internet connectivity, became a determining factor for educational continuity, especially affecting students and teachers from low socioeconomic levels and rural and marginal urban areas (Baber, 2021).

As health restrictions were lifted and some of the technological challenges were overcome, virtual education began a process of formalization (Jie & Sunze, 2022). However, significant questions remain about the impact of technological infrastructure on educational processes during the pandemic. In this context, the following research question arises: How did technological infrastructure affect teaching-learning processes in educational institutions during the COVID-19 pandemic according to the available scientific literature?

The role of technologies in facilitating effective learning was already recognized before the pandemic (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015). However, the health crisis highlighted the crucial importance of having adequate technological infrastructure, especially in rural and marginalized areas (Executive Order 1419, 2020). Disparities in accessing technology and connectivity revealed pre-existing inequalities, negatively affecting educational quality and equity. In response, the Colombian government mandated through Executive Order 1419 (2020) that community television operators offer internet services in rural areas to guarantee access to information and communication for the most vulnerable. Two years later, the public policy on educational resource management (Ministry of National Education of Colombia and Regional Center for Book Promotion in Latin America and the Caribbean [MEN-CERLALC], 2022) continues emphasizing the urgency of advancing in the design and use of digital and hybrid educational tools to close the persistent gap in access to Information and Communication Technologies (ICTs) in rural, urban, and marginalized sectors. Furthermore, it is considered vital that these resources be accessible, flexible, durable, modular, portable, and reusable to ensure their quality. In the African context, where technological infrastructure is even more limited, UNESCO (2021) has emphasized the need to improve access to digital devices and connectivity to reduce the educational inequalities the pandemic has further intensified.

Moreover, the rise of virtuality in the educational context responds to an increase in this training modality by adult learners with work and family responsibilities (Martin & Bolliger, 2023). However, a low student retention rate has been reported (Australian Government Department of Education, 2023), primarily attributed to a lack of digital skills, as well as a lack of motivation and satisfaction (Wagiran et al., 2022). In this context, technological mediations play a crucial role. They are understood as a set of tools, contents, strategies, capabilities, and regulations that optimize communication and learning between basic and higher education students and teachers, using ICTs. In this sense, technological mediations must be meticulously designed, planned, and implemented, considering strategies, resources, and materials and taking into account the objectives, contents, media, scenarios, and actors of the educational process (Muñoz, 2016).

The relevance of technological infrastructure in education is a decisive issue in the current context, in which technological mediations are essential to improve and dynamize educational processes. According to Jara (2015), technological infrastructure in education comprises a set of resources and services that facilitate access, use, and management of information in the academic environment. They include devices, networks, platforms, applications, contents, and technical support, all designed to foster interaction between teachers, students, and their families in virtual environments. Having an adequate technological infrastructure is essential to promote educational quality from an inclusive and equitable education that is aligned with the demands and challenges of the 21st century. However, its implementation and maintenance need strategic planning, sustainable investment, and adequate training of educational actors.

Currently, there are different teaching methods in which the use of technological tools such as computers and Internet connectivity is indispensable. Distance and hybrid teaching have replaced in-person classes. However, for science and mathematics teaching, the following have been identified as the main challenges: advanced technological equipment and tools, along with specialized software and access to licenses that are mostly paid (Ergüzen et al., 2021), in addition to the results of the latest World Bank report indicating that until 2021, only 63% of the world's population had access to the Internet (World Bank, 2023), which hinders the universalization of these educational approaches.

For in-person ICT or hybrid classes, Turgut and Aslan (2021) indicate that factors such as the physical environment, institutional control, and access to websites limit ICT incorporation. In addition, these factors include technical equipment, adequate infrastructure, and continuous training. Innovations such as the implementation of Virtual Augmented Reality (VAR), despite their proven contributions to education, have the same limitations mentioned above, with the additional expensiveness of their use since, according to Marks & Thomas (2022), the cost of implementing this technology in a laboratory amounts to 76,563 U.S. dollars, while the OPERATION cost per semester amounted to 19,248 U.S. dollars, resulting in an average cost per session of 19.5 U.S. dollars. Many educational centers in South America and the world cannot afford this investment.

The immersion of innovation brought by technologies and platforms in education has great potential for the coming years, as mentioned by Shurygin et al. (2021), noting that they develop personalized and engaging learning experiences that can be retained, applied, and implemented (p. 71). However, technologies such as augmented reality (VAR), 4D printing, holograms, and artificial intelligence are still under development, and as noted by Marks & Thomas (2022), the implementation and use costs are high. Even so, virtual learning platforms such as Duolingo, Moodle, Zoom, IBOX, and others are already being used in contemporary education that promote the social-constructivist theory and social learning as they incorporate collaborative-based interactions (Barfi et al., 2023).

The incorporation of educational technologies not only benefits students but also facilitates teachers' work by making it possible to create, manipulate, share, and use information (Kouser & Majid, 2021). The cognitive factors related to the use of technological tools influence time, self-regulation, learning tasks, and collaborative learning (Bizami et al., 2023). Likewise, educational platforms such as Kahoot, Quizziziz, and Quizalize have been found to have gamification features

that motivate students and improve their retention in learning (España-Delgado, 2023). In addition, the simplicity of use of these tools facilitates the flipped learning model and its effectiveness in synchronous classes (Dianati et al., 2020).

The use of digital content in pedagogical activities ranges from prenatal education programs for expectant mothers (Whitworth et al., 2023) to the implementation of special educational programs for societies affected by armed conflicts (Habib, 2023). Digital content enables the use of various information formats, such as PDF and Word, among others, platforms such as social media, web pages, and devices such as computers, cellphones, and tablets, among others, to offer users a better experience and satisfaction of use (Eichen et al., 2021; Horst & Hitters, 2020; Stevens et al., 2021). In this context, the inclusion of digital content that complements the curricula keeps students' motivation activated, especially in online classes, in which teachers cannot easily see if their students are bored (Fansury et al., 2020).

From a more efficient and environmentally sustainable approach, these resources optimize the teaching process, save time in the transfer of information, and, from an ecological perspective, reduce paper and ink consumption, enabling students to modify and generate new knowledge from existing knowledge, and reduce physical storage space (Haleem et al., 2022). For example, e-books, which have the same functionalities as a conventional book, can include multimedia and interactive content that reinforces their content (Hidayat-ur-Rehman et al., 2020).

The design of courses that incorporate technological tools and ICTs should be developed under an approach based on a learning management system that includes characteristics of traditional learning and information and communication technologies and electronic learning tools (Samoylenko et al., 2022). In this regard, West (2023) mentions the existence of two theories for the design of Free Digital Distance Education (ODDE). The first, called imported theory, is transferred from other disciplines and implemented in digital pedagogy; the second, called original theory, is specific to the pedagogical discipline and is still under development due to its rapid changes.

The simplification and optimization role of technology in educational processes has been frequently mentioned. The ability to improve teaching performance through efficiency in terms of time, assessment, learning control, and student retention (Haleem et al., 2022) is fulfilled as long as teachers have sufficient digital skills to take advantage of these tools since technology alone does not adequately prepare teachers for their job success, even if optimally designed and structured (Meier, 2021). Furthermore, Baldwin and Ching (2020) emphasize that, taking advantage of the widespread use of cellphones, to ensure compatibility, availability, optimization, and proper navigation in adapting professional training courses to these devices is essential.

Beyond a curriculum for the training of future teachers of the youth of the future, it is necessary the intervention of educational institutions and the State itself because the latter is the only one capable of determining the main guidelines for teacher training through policies that ensure a teaching process in line with the requirements of the new educational demands (Pirela et al., 2022). From a more immediate intervention, that is, from the educational establishment, there are models such as the Technological Pedagogical Content Knowledge (TPACK) that continuously instruct teachers to improve teaching activities (Balladares-Burgos & Valverde-Berrocoso, 2022).

In this context, technological tools play a crucial role as facilitators of the democratization of educational access and the promotion of equality. However, the educational reality in Latin America is still far from reaching the concept of education defined by the United Nations. This motivated the creation of the Latin American Conference on Learning Objects and Educational Technologies (LACLO). This initiative aims to discuss and explore new trends and strategies in education (Frango et al., 2021).

Moreover, a significant global challenge is to ensure the accessibility of education for students with disabilities. In this sense, the Universal Design for Learning (UDL) model constitutes a fundamental guideline for the development of inclusive courses and pedagogical activities. It also establishes that education should give students the possibility of accessing education, choosing the most appropriate format for their interaction, according to their learning style (Crisol-Moya et al., 2020). As pointed out by Crisol-Moya et al. (2020), it is possible to have an equitable education as long as students are taken into account, a useful platform and technological resources are available, and there is trained human talent since these factors are determinants in the effectiveness of education. The main objective of this work is to determine how the technological infrastructure affected the academic dynamics in educational institutions (IE) during COVID-19 isolation through a systematic review of the available scientific literature.

METHOD

Design

The study was conducted through a systematic literature review (SLR) based on the PRISMA method (Uman, 2011) to analyze previously published results, identify and explore contradictions in the state of the art (Quispe et al., 2021), answer research questions that have not been addressed in individual studies (Page et al., 2021), and generate knowledge applicable to different users about technological mediations in educational processes (Gough et al., 2019). In addition, the SPICE (Setting, Perspective, Intervention, Comparison, and Outcomes) method was used to delimit the research scope, which included the collection of publications from the last five years.

Instruments

The instruments used in this study include:

Academic databases and institutional repositories

Resources such as Scopus, DOAJ, ERIC, and Google Scholar were used to identify relevant studies that met the established inclusion and exclusion criteria.

Data analysis tools

Specific software for qualitative and quantitative analysis, such as NVivo and SPSS, will be used to examine the results obtained from the selected studies.

Search and selection criteria

Boolean phrases and connectors were used, such as `("technological mediation" OR "ICT integration") AND ("education" OR "learning process" OR "teaching process")`. The inclusion criteria were writing in English or Spanish, availability of complete documents, and focus on basic and higher education. Table 1 shows the results of the initial search.

Table 1.
Results of the first database search

Source	Descriptor	First results	Inclusion criteria
Scopus	("technological mediation"OR" ICT integration") AND ("education"OR"learning process"OR"teaching process")	331	42
DOAJ	'Technological Medication OR ICT integration 'AND 'education OR learning process OR teaching process'	1071	53
ERIC	("technological mediation"OR" ICT integration") AND ("education"OR"learning process"OR"teaching process")	49	10
Google Scholar	("technological mediation"OR" ICT integration") AND ("education"OR"learning process"OR"teaching process")	16900	452
Total		**18351**	**557**

Procedure

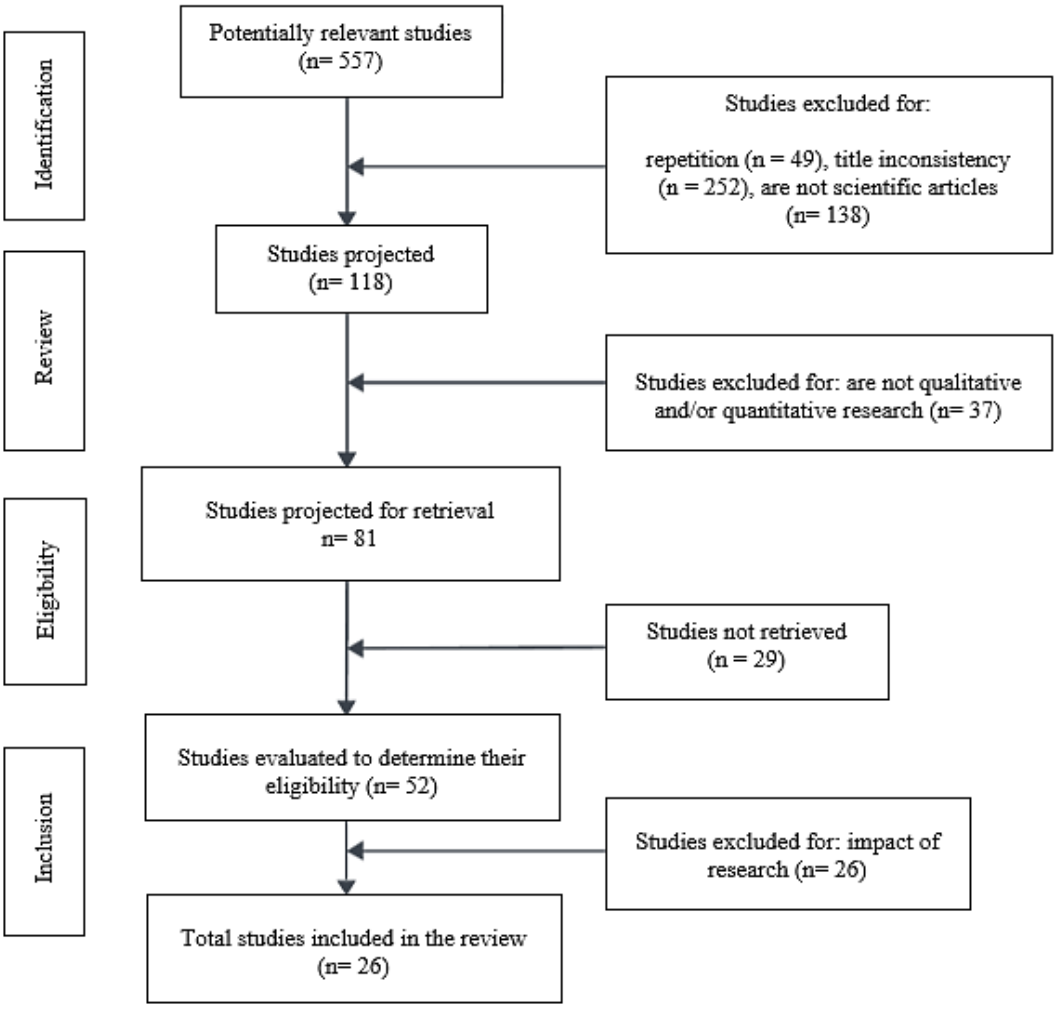
First, the above databases were thoroughly examined to locate studies that met the inclusion and exclusion criteria. Next, the PRISMA method was used to select the relevant studies. Then, the selected articles were exhaustively analyzed to identify contradictions and answer the research questions posed. Finally, the SPICE method was used to guide the structure of the systematic review.

Data analysis

Specialized tools were used for both qualitative and quantitative analysis, which are described in the Instruments section. These tools evaluated the effects of technological integration and mediation on the academic performance, engagement, permanence and independence of 11th-grade students with learning disabilities in educational institutions in Colombia.

Subsequently, a second filter was applied, considering factors such as repetition, type of research, studies not retrieved, and the relevance of the research within the scientific community. Figure 1 shows the PRISMA flow chart for this second filter of bibliographic sources.

Figure 1.
PRISMA flow chart



RESULTS

After the search for bibliographic sources to carry out the systematic review was conducted, it was found that most of the publications corresponded to 2020, while for 2019, it was found that no publications met the established inclusion criteria (see Figure 2). In addition, the application of the research focused primarily on undergraduate higher education in various specialties, although studies focused on foreign language teaching-learning and the training of professionals in Pedagogy and Health were also identified (see Figure 3).

Figure 2.
Bibliographic references by year of publication

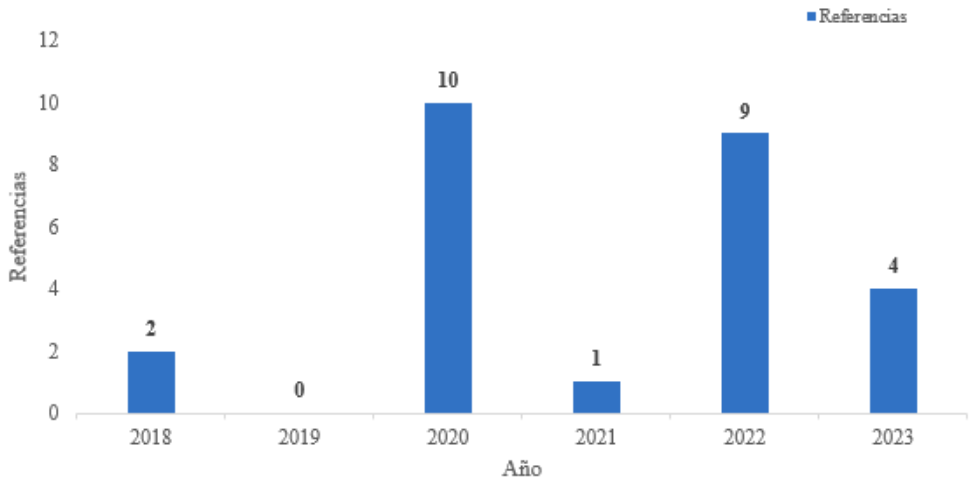


Figure 3.
Bibliographic references by application

Table 2 presents the bibliographic sources consulted for this systematic review of the literature.

Table 2.
Bibliographic references consulted.

No.	Tool	Application	Description	Reference
1	Tablets, computers, cellphones, and Internet	Higher education in underdeveloped countries during the pandemic.	A cross-sectional and quantitative study to assess the background and factors of e-learning implementation. The results show that, despite the lethality and mortality of the pandemic, e-learning was reinforced and generalized, aided by the diversification of technological elements such as tablets, computers, cellphones, and Internet connection.	Adzovie & Jibril (2022)

Table 2.

Bibliographic references consulted (continued)

No.	Tool	Application	Description	Reference
2	Web 2.0	Teacher professional training at a Turkish university.	A qualitative study assessing the collaborative project-based learning (CPBL) method. The study concludes with an improvement of problem-solving skills, critical thinking, motivation, and self-regulation, even though at the beginning of the program the test subjects found it difficult to use Web 2.0.	Kamali et al. (2022)
3	Macro Process software	Business higher education	A quantitative study that analyzes the mediating effects of the expectancy confirmation, flow theory, and student retention model on the acceptance of technological learning. The results prove that confirmation and flow are highly significant mediators, while student retention is negatively correlated with intentionality to continue technological learning	Tseng et al. (2022)
4	Virtual learning environment	Health professionals training	A quantitative and qualitative study that assesses the impact of a Virtual Learning Environment (VLE) compared to traditional learning and the degree of student satisfaction. The results reveal a positive impact on the final grades in the VLE, as well as a high degree of satisfaction. However, since the VLE needed three times more time than the traditional one, a decisive comparison is very complicated.	Afonso et al. (2018)
5	Zoom Platform	Foreign language learning	A quantitative and qualitative study that assesses computer-mediated communication through the Zoom platform. The results evidence that the Zoom platform generates an autonomous and collaborative learning environment that connects learners with each other to improve their language skills. However, the effect of feedback was not assessed in this study, so it would be interesting to consider it in other studies.	Lenkaitis (2020)
6	Various technological tools	Virtual tutoring in higher education	A mixed-type research (quantitative focal study and qualitative cluster sampling study) that combines a quantitative focal approach and a qualitative cluster analysis aimed at improving virtual tutoring services in educational processes. According to the results, factors such as communication via chat, student learning styles, availability of the virtual learning environment, and computer mediation strategies are identified with the lowest ratings.	Ramírez et al. (2020)
7	Various technological tools	Pedagogy professionals training	A qualitative study of a descriptive-analytical scope that analyzes and characterizes the course syllabus sheets in pedagogical training. The results specify that, despite the inclusion of ICTs in the curriculum, future teachers do not develop the digital skills necessary to improve their job performance.	Vieira & Pedro (2023)

Table 2.
Bibliographic references consulted (continued)

No.	Tool	Application	Description	Reference
8	Mobile technology	Foreign language training	A quantitative study that examines the factors involved in the use of ICTs in teaching-learning processes in the first years of the teaching undergraduate program and the context of the pandemic. The results indicate that novice teachers are more willing to incorporate ICTs when they receive help from both the management of the educational institutions and their colleagues. In addition, positive experiences with ICTs emerge when teachers perceive themselves as self-efficient, improving their motivation to use ICTs.	Jie & Sunze (2022)
9	Various technological tools	Teacher performance during the pandemic.	A quantitative study that analyzes the factors involved in the use of ICTs in teaching-learning processes in the first years of the teaching undergraduate program during the pandemic. The results suggest that novice teachers are more willing to incorporate ICTs when they receive help from the management of the IE and their colleagues. In addition, positive experiences with ICTs emerge when teachers perceive themselves as self-efficient, improving their motivation to use ICTs.	Paetsch et al. (2023)
10	Various technological tools	Music teaching and learning	A qualitative study that analyzes the teaching and learning activities using ICTs during the pandemic. It was found that most teachers used more reproductive than constructive activities, focused on learning and verbal assessment, with collaborative activities being the least frequent.	Pozo et al. (2022)
11	Various technological tools	Engineering higher education	A qualitative study that examines the opinions and practices that delimit the conceptions of the use of ICTs in the teaching of university engineering instructors. The findings provide five categories: information delivery, transmission of structured knowledge, guided learning, student involvement in practice, and innovation. In addition, it was found that the use of ICTs underlies the teacher's pedagogical approach.	Khalid et al. (2023)
12	Moodle Platform	Islamic Studies higher education	A quantitative approach study that measures the level of LMS implementation in the Moodle-based e-learning dimensions. The results show that the use of Moodle-based e-learning is optimal in the learning implementation and assessment. Therefore, improving the quality of the application, the support available, and the user capabilities is suggested.	Makruf et al. (2022)
13	Moodle Platform	Foreign language training	A quasi-experimental study focused on analyzing the effectiveness of Moodle in hybrid second language learning. The results suggest that the Moodle platform had a positive influence on the performance of the learners, with the latter obtaining higher grades and preferring this tool.	Acar & Kayaoglu (2020)

Table 2.

Bibliographic references consulted (continued)

No.	Tool	Application	Description	Reference
14	Plataforma Moodle	Higher education assessment method	A quantitative study that analyzes the application of Moodle with basic questionnaires (BQ) and thematic block questionnaires (TBQ), the latter being the most suitable as assessment tools, while the former as formative tools. The result is that Moodle is a reliable tool for learning scientific topics.	López-Tocón (2021)
15	Artificial intelligence	Regular basic education and according to the learning style of each student	A quantitative study focused on the development and measurement of the impact of AI-based learning style prediction in a Moodle-based learning portal. The results show a change in the learning environment of school students as AI adapts the subject according to the learning style of the student. The study emphasizes the active participation of teachers to explore learning materials that suit their students.	Pardamean et al. (2022)
16	Artificial intelligence	Rating assessment	The study focuses on the implementation of AI and learning analytics to address uncertainties related to peer assessment systems. The results evidence that this approach enables students to provide more significant feedback, assigns the student's grade reliably and accurately, enables students to give peer feedback in peer review situations, and enables teachers to assign recommendation systems to optimally identify situations in which teacher supervision is needed.	Darvishi et al. (2022)
17	Social media	Higher education teaching	This study explores how academics have adopted the use of social media to enhance their pedagogy in a resource-constrained context. The study reveals that academics created a social media-based teaching-learning environment that enhances collaborative learning and student concentration. The author recommends the use of social media in pedagogical practices because it generates flexibility, collaboration, and communication, but also entails some cons that should be taken into account through regulations and educational standards.	Vandeyar (2020)
18	Technology and Social media	Higher education	The study examines the use of social media by university faculty, administrative staff, and students. The results reveal that Facebook, LinkedIn, ResearchGate, Twitter, and Yammer are the most frequently used social media. There is a tendency to use them professionally due to the pressure to improve their performance and prevent wasting time in such apps.	Aldahdouh et al. (2020)
19	YouTube Platform	Listening skills in foreign language teaching	A qualitative descriptive approach study that explores the impact of YouTube on English teaching and learning, as well as the challenges it poses for teachers. The article concludes that YouTube attracts students' attention and stimulates their creativity and covers the materials thoroughly, especially language. In addition, it introduces the element of fun by satisfying students' interests. There is a noticeable impact on the learning process because the educational environment is more uplifting and inspirational.	Hussaeni et al. (2020)

Table 2.
Bibliographic references consulted (continued)

No.	Tool	Application	Description	Reference
20	YouTube Platform	Higher education learning and tutoring	A quantitative study that examines students' perceptions of the use of YouTube as an educational tool for learning and tutorials. The main results suggest that perceived usefulness of YouTube had a more significant impact on students' perceptions toward learning through YouTube compared to perceived ease of use.	Maziriri et al. (2020)
21	Virtual Reality	Higher education laboratory	An experimental assessment of the implementation of a virtual reality laboratory for 5 semesters. The economic results show expensive implementation, operation, and use costs. However, an increase in student attendance and a perception of improvement in student academic performance was observed.	Marks & Thomas (2022)
22	Kahoot, Quizizz, and Quizalize	Foreign language teaching and learning	The study explores student perception of the implementation of gamified learning platforms based on Kahoot, Quizizz, and Quizalize. The results revealed that Quizizz was the most preferred platform by the students because it had several functionalities that made it exciting and motivating. However, the authors highlight the importance of connectivity since it could constitute a negative factor.	España-Delgado (2023)
23	Moodle, Open EdX, and NEO LMS	Higher education	This study compares the three learning platforms in relation to student academic performance in universities in Russia and China. The test results after working with the Moodle platform reveal that the students with different academic performance improved their grades. The most significant improvement took place in students with “failing” grades; more than 50% improved their grades.	Liu et al. (2020)
24	e-learning platforms	Higher education	The article explores and analyzes the factors that influence academic performance and student satisfaction when using e-learning platforms. The authors identified that factors such as students' prior experience, collaboration, interaction, and autonomy influence student academic performance and satisfaction when using e-learning platforms. The results of the study indicate that the above factors have a positive impact on student satisfaction and academic performance.	Abuhassna et al. (2020)
25	Digital media	Higher education	The study focuses on the perceptions of teachers and students on the use of digital media. The findings indicate that both teachers and students use a limited number of digital technologies, mainly for assimilative tasks, with the learning management system being the most frequently used tool.	Bond et al. (2018)
26	Digital media	Higher education	The article explores and develops a mobile learning-based video game called Quiz Time for use in higher education. This pedagogical game uses a fuzzy model intelligence to assess, support, and personalize programming language learning. After being assessed during a semester, computer science and education specialists highlighted the importance of the game, while students emphasized its positive effect on learning and its usefulness in achieving more specialized knowledge in the subject.	Troussas et al. (2020)

DISCUSSION

First, it is important to mention that, according to Adzovie and Jibril (2022), the COVID-19 pandemic has positively encouraged the inclusion of e-learning strategies in higher education (p. 6). According to the same author, the availability of digital tools in teachers and students extended the use of digital learning. In this context, Kamali et al. (2022) highlight the importance of Web 2.0-based e-learning, integrated into collaborative learning projects, as a tool to develop problem-solving and critical thinking skills with democratic attitudes in the participants. This approach also increases motivation and self-regulation through technological learning. In addition, in implementing electronic elements and mobile applications, the expectation confirmation and flow theories can serve as indicators of students' intention for continuity and acceptance of the technological strategy (Tseng et al., 2022). However, the active participation of teachers and the availability of technical equipment is essential to assess the quality and effectiveness of these tools, ensuring a positive response from the students.

"To effectively incorporate digitalization in university education, it is essential to use computers and mobile devices as mediators in the teaching-learning processes, contents, and learners and teachers, based on a pedagogical approach" (Ramirez et al., 2020).

For Adzovie and Jibril, (2022), effectiveness and efficiency depend on the understanding of the background and the main challenges in their adoption. To this end, the management of IEs and the public bodies must provide the necessary logistics and infrastructure, such as equipment and Internet connectivity (Adzovie & Jibril, 2022; Ramirez et al., 2020), as the youth constitutes in the present and future the main adopters and innovators in the use of these tools. This population includes both teachers and students in research activities and technological innovation in the use of ICTs (Adzovie & Jibril, 2022; Vieira & Pedro, 2023).

Self-efficacy significantly influences the use and integration of ICTs in teaching-learning processes. Paetsch et al. (2023) found that the more self-efficient teachers perceive themselves to be, the greater their tendency to use ICTs. However, the study also highlights the importance of having strong technical and emotional support from colleagues and directors. According to Pozo et al. (2022), teacher behavior in teaching-learning activities with ICTs is reflected in the reproduction of knowledge rather than in the construction of knowledge. In this same line, Khalid et al. (2023) suggest that if teachers consider that ICTs do not improve their pedagogy, an ICT implementation program will not be effective for those particular teachers.

According to Afonso et al. (2018), technological mediation is fundamental in knowledge construction between teachers and students. Virtual Learning Environments (VLEs) should include printed and audiovisual elements and software that present information in a dialogic and contextualized manner to promote meaningful learning and improve cognitive performance. This study suggests that VLEs should be focused on the flow theory (Tseng et al., 2022). Also, according to Lenkaitis (2020), in a videoconference on the Zoom platform for second language learning, it was observed that the participants generated a socio-constructivism-based collaborative environment. The students actively participated in their learning through online collaboration and exploration without teacher intervention (Jie & Sunze, 2022). However, it was identified that the learners being

studied often discussed trivial topics that did not require greater knowledge, limiting the effectiveness of unsupervised learning processes (Lenkaitis, 2020). It was also found that the learners under this study often discussed trivial topics that do not demand greater knowledge, limiting the effectiveness of learning processes without teacher supervision. Similarly, Jie & Sunze (2022) highlighted that mobile learning is at an incipient stage in global education systems since there are insufficient assessments to show its impact on academic performance.

Regarding the use of e-learning platforms, Makruf et al. (2022) emphasize the availability of technical infrastructure, reliable physical facilities, bandwidth, management, and digital competencies of academic staff and faculty. They identify as dimensions the planning, implementation, and assessment of such platforms, with *Moodle* being the least optimal in the last two dimensions due to the quality of the system, support facilities, user capacity, and optimization of the system from the users (students and teachers). However, like Lenkaitis (2020) about Zoom, Acar and Kayaoglu (2020) highlight the motivational and individualized learning capabilities *Moodle* can offer students in second language teaching. López-Tocón (2021) reported a continuous study behavior in physics and chemistry students by implementing two types of controls: basic questionnaire and thematic block questionnaire, increasing the number of students passing with minimum, outstanding, and honors grades.

The use of artificial intelligence also has promising applications in pedagogy, as Pardamean et al. (2022) prove in assessing a learning style prediction system for a basic education IE. The author of the citation emphasizes the usefulness of AI in the academic improvement of learners and the possibility for teachers to become aware of changes in their students' styles, making it possible to plan, implement, and assess new pedagogical strategies and educational content. Darvishi et al. (2022) developed an AI-assisted analytical approach to optimize the reliability aspects of peer assessment systems. Their main results contemplate feedback skills, accurate assessments, and identification of teaching intervention.

Furthermore, (Vandeyar, 2020) points out that the use of social media as an alternative teaching method in contexts of limited resources gives good expectations since the LMS (Learning Management System) found it difficult to implement them due to problems of connectivity, technological infrastructure, and availability of adequate hardware and software. The main pedagogical activities are live broadcasts and comment blogs, which meet the "ease of use" and "perceived usefulness" constructs of the Technology Acceptance Model (Davis, 1993). According to the same study, teachers showed three major changes: abandonment of LMSs, change in beliefs and attitudes, and a pedagogical shift (p. 5633). Similarly, Aldahdouh et al. (2020) highlight the indispensability of social media in the daily activities of academics in universities and institutes as they suggest that IEs should improve technological capabilities, disseminate work through social media, and participate in scientific dialogues on the Internet. The authors comment that this environment of technologization of academic activities would contribute to the continuous professional development of professors, promote the generation of knowledge in a summarized and concise way, and imply an interaction of scopes beyond classes with students. From the institutional side, there would be an increase in scientific indicators, prestige, and ranking of an institution (Al-Daihani et al., 2018).

For its part, YouTube is considered a valuable tool for learning, especially in second language teaching. According to Hussaeni et al. (2020), this platform can retain students, improve listening skills in the language, and contextualize the topics covered. For this, the authors highlight that it is important for the content to have a long enough duration to convey the information without being excessively long. This is in line with what Aldahdouh et al. (2020) mention in the context of social media by pointing out that the information presented should be useful and concise, without the usual length of academic articles. In line, Maziriri et al. (2020) emphasize the importance of the constructs of "perceived usefulness" and "ease of use" of YouTube, making it a positive and meaningful tool for learning.

Virtual Reality (VR) is also advancing rapidly in the optimization of teaching-learning processes. As shown by Marks and Thomas (2022) in their research, when implementing a VR lab at a university, a high attendance rate (250%) was observed in students and faculty from different professional specialties. However, some deficiencies included the scarcity of available courses and the slow process of creation by technicians, in addition to the discomforts perceived by students when using the facilities. Economic constraints were also considered for contexts with limited resources.

Chaiyo and Nokham (2017) mention that the integration of gamified activities through platforms such as Kahoot, Quizziz, and Google Forms in education "supports learning and increases student concentration, participation, enjoyment, and motivation" (p.182). Moreover, generating a competitive environment among learners, especially when the video game includes functionalities such as power multipliers or rewards, increases motivation (España-Delgado, 2023). However, España-Delgado (2023) points out that collaborative behavior may be affected by competitiveness. Another gamified learning proposal was proposed by Troussas et al. (2020) who developed a mobile application with artificial intelligence to promote personalized and collaborative learning in computer science students.

Regarding technology adoption, Abuhassna et al. (2020) mention that "students first make sure that the use of e-learning platforms can meet their study needs or is relevant before they consider using such technology in their learning" (p. 15). From the teaching perspective, Liu et al. (2020) emphasize factors such as free access, low training costs, the possibility of dividing the e-course content into modules, the training flexibility, the capacity to keep updated, and the capacity to assess the knowledge acquired. However, Bond et al. (2018) found that the use of ICTs by teachers of the University of Germany was limited to organizational activities rather than being promoters of constructivism or socio-constructivism, coinciding with the persistence of teacher-centered teaching-learning processes (Marcelo & Yot-Domínguez, 2019).

The COVID-19 pandemic has significantly impacted the adoption of higher education digital learning strategies, leading to an increased use of web-based e-learning and collaborative learning projects that foster critical thinking attitudes and problem-solving skills. However, the success of these implementations depends on the proactive participation of the faculty and technical teams, as well as the provision of necessary resources, including access to devices and Internet connectivity, especially for populations with limited resources.

Technology integration improves learning results, but it is critical to guarantee the quality and effectiveness of these tools to ensure positive response from both students and teachers. In addition, helping teachers improve their self-efficiency in the use of technology can lead to more meaningful adoption of ICTs. It is also crucial to promote a pedagogical shift from a teacher-centered to a student-centered approach that integrates technology. A future research direction could focus on identifying factors that influence the effectiveness of digital learning technologies, including the assessment of the impact of the use of artificial intelligence, mobile learning, social media, and virtual reality on classroom teaching. The use of gamified approaches and interactive technologies to increase student motivation and learning results could also be studied.

In this context, although the adoption of technology in education has increased significantly, research can help to better understand the characteristics of the barriers that persist and explore possible strategies to overcome them. Further research in these areas could expand our understanding of the benefits of digital learning in education.

The information extracted from the study on post-pandemic technological mediations in the teaching-learning processes in educational institutions reveals a series of significant effects on various academic and motivational aspects.

First, technology integration and mediation have been shown to have a positive impact on student academic performance. The introduction of technological tools, such as gamified applications capable of predicting learning style, has provided an interactive and personalized learning environment, enabling students to address their difficulties more effectively and adaptively. This is reflected in improvements seen in academic results and the perception of teachers and students as technology facilitates access to varied educational resources and offers innovative methodologies that are tailored to the individual needs of students.

In terms of motivation, technological mediation has played an essential role in increasing student interest and participation. Digital tools have transformed the learning experience, making it more engaging and relevant to students. The capacity to use interactive applications, simulations, and multimedia content based on the concepts of “perceived usefulness” and “ease of use” has contributed to maintaining students' interest, which, in turn, has increased their intrinsic motivation toward learning.

In terms of knowledge retention, the integration of technology has proven effective in providing multiple channels for the acquisition and consolidation of information. The diversification of educational resources, such as educational videos, interactive platforms, and multimedia materials, has facilitated a comprehensive approach to learning. In addition, it has created an environment that fosters professional development in academic sectors and the overall prestige of the institutions. This has strengthened knowledge retention by addressing different learning styles and reinforced the understanding of concepts through various modalities.

In terms of student autonomy, technology has promoted independence in learning. Access to online resources, the possibility of accessing educational content anytime and anywhere, and the incorporation of interactive elements have empowered students to take a more active role in their

educational process. This has promoted the development of self-directed skills and the capacity to manage their learning.

It can be roughly concluded that technology integration and mediation have the potential to be key elements in improving the academic performance, motivation, retention, and autonomy of 11th-grade students with learning disabilities in an educational institution in Colombia. These findings found in the international literature and diverse development contexts suggest that the strategic implementation of technology in the classroom can have a significant impact on the educational experience and contribute to the integral development of students. However, it is important to keep in mind that the Latin American reality is very different from that of other continents, so it would be advisable to plan, implement, and assess pedagogical strategies adapted to the Latin American and Colombian context.

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