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Tools and New Information and Communication Technologies

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New information and communication technologies (ICT) have become essential in our daily lives, including the educational system. Their integration as an educational tool holds great potential for innovation and improving the quality of teaching. This analysis covered various tools and emerging technologies that facilitate and optimize the teaching-learning process. Using the SCOPUS and Web of Science databases and following the PRISMA statement, 72 out of 557 publications met the inclusion criteria. The results revealed growing academic interest in educational technological solutions, with a significant increase in publications between 2019 and 2022. Areas such as e-learning, online communication, and multimedia platforms have been widely researched, while artificial intelligence, virtual reality, augmented reality, and gamification have gained increasing attention. One key challenge identified is the digital competence of educators, highlighting the need for comprehensive training programs. Current trends focus on enhancing teaching and learning, immersive virtual environments, meaningful learning, student autonomy, teacher training, collaborative skills, and self-directed learning. These findings suggest a wide range of technological tools applied to education, with the potential to improve innovative educational practices.

Keywords: new technologies, systematic review, technological tools, educational and NICT's

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Introduction

Technology has become a necessary tool in all areas of our daily lives, both personal and professional, including the educational system itself. Since the starting point of the technological revolution, here represented by the invention of the telephone and telegraph in the second half of the 19th century, the evolution brought by the creation of the internet and its extensions has produced unstoppable changes in the way we communicate, work, and learn (Alférez-Pastor, Collado-Soler, Lérida-Ayala, Manzano-León, Aguilar-Parra, & Trigueros, 2023).

Notably, this continuous evolution and propagation of information and communication technologies (ICTs) in our lives have led to great interest in their application to education, given their capacity to facilitate various forms of communication and support the production, storage, and use of information (Dele-Ajayi, Fasae, & Okoli, 2021). Their use as an educational tool can be seen as positive and of great potential, given characteristics such as easy access, portability, and immediacy. However, the most commonly described advantages for education are improved learning engagement, support for active and collaborative learning, fostering creativity, enhancing the effectiveness of the communication process, and critical thinking (Qian & Clark, 2016; Ravenscroft, Warburton, Hatzipanagos, & Conole, 2012).

The integration of ICTs in education is, therefore, a topic of great relevance in the global context, with the potential to promote innovation and improve the quality of teaching, enabling more dynamic, collaborative, and personalized pedagogical practices (Behar, Siqueira, & Reinhardt, 2020; Cristóvão, Verdasca, Ramos, & Rebelo, 2022; Margolis, Nussbaum, Rodriguez, & Rosas, 2006). These practices have significant impacts on students' educational achievements, providing them with access to multiple learning resources and enhancing educational materials, resulting in more engaging and interactive classes. This approach favors more individualized teaching and student autonomy, given the possibility of completing tasks with geographical and temporal freedom, encouraging them to be protagonists of their own educational journeys (Cristóvão et al., 2022; Mentsiev, Aygumov, & Zaripova, 2023; Spiezia, 2011).

Nonetheless, effective integration demands understanding not only the potential of technological tools but also the challenges and specific needs of the Brazilian educational context (De-Sena, 2023; Len, Encinas, Vaquero, Dios, & Ruiz, 2009), where its diversity and particularities require innovative and adaptive approaches (Behar et al., 2020). In educational practice, ICTs face significant challenges ranging from issues related to technological infrastructure and internet access to the adequate and continuous training of teachers, with a focus on using digital technological tools (Behar et al., 2020; De-Sena, 2023). It is also necessary to address the barrier of socioeconomic and regional inequalities, specifically regarding the use of ICTs in the educational environment (Stevanim, 2020).

In this regard, the emergence of Education 4.0, part of a fourth industrial revolution characterized by the integration of advanced digital technologies such as artificial intelligence, big data, and the Internet of Things, has further expanded the possibilities for innovation and improvement in educational practice (Kshirsagar, Jagannadham, Alqahtani, Naveed, Islam, Thangamani, & Dejene, 2022). However, according to Führ (2018), Brazilian education needs professionals well-versed in "technopedagogy" to meet the new demands of this educational reconfiguration, including: interdisciplinarity, transdisciplinarity, new information and communication technologies, digital interactivity, maker culture, artificial intelligence, autonomous learning, a contextualized and flexible curriculum, hybrid teaching, collaborative environments, digital teaching materials, the Internet of Learning Things, computational critical thinking, among others.

Führ (2018) notes that even amid the demands of Education 4.0, many educational institutions have not effectively adopted ICTs as teaching-learning tools for the new digital student, who yearns to be challenged and learns anywhere, anytime. He believes that there are analog educators resistant to the inevitable technological metamorphosis of today's society. Added to this context is the need to reformulate course and institutional pedagogical projects to incorporate the use of ICTs into the curricula, as well as the necessity for continuous professional training.

In the same vein, the resilience of the educational system, an intrinsic quality that allows educational institutions to adapt, withstand, and recover from unexpected challenges (Henderson, Noble, Osborne, & Weston, 2018), has become an essential characteristic for the sustainability of education. This resilience heavily depends on ICTs to enhance the teaching-learning process and ensure the continuity of education. Nevertheless, in line with the thoughts of Cox and De-Bortoli (2022), implementation in academic processes should not overlook certified basic requirements, such as student competencies, skills and understanding, critical self-analysis by teachers, an organizational culture for process implementation, and a management model.

In light of the aforementioned, this systematic review aims to achieve a comprehensive and up-to-date survey of the information and communication tools and technologies available to support the educational process. Through critical analysis of recent literature, it seeks to identify the main trends and advances in this field, providing insights for educators, administrators, and researchers interested in promoting innovative and inclusive educational practices that meet the specific needs of the Brazilian context.

Given the relevance and necessity of knowledge regarding the widest possible range of technologies aimed at the field of Education, the present study sought to answer the following questions: What information and communication tools and technologies are available to support the formal educational process in different contexts? What is the distribution over time of the publications included in this review? What are the main applications indicated for these tools?

Method

This article conducted a systematic literature review, employing a comprehensive search for scientific articles to compile a list of relevant studies addressing information and communication tools and technologies available and applicable to formal education, following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page et al., 2021). The databases used were Scopus and Web of Science (WoS), chosen for their comprehensive coverage and adherence to rigorous scientific criteria for research dissemination. The search was conducted in five main stages: (a) formulation of the research question, (b) identification and screening of studies, (c) data extraction and synthesis, (d) screening of included studies, and (e) analysis of results.

Formulation of the Research Question

Given the impacts of ICTs on the educational process and aiming to contribute to the actions of educational actors, we sought to identify information and communication tools and technologies available to support the formal educational process in different contexts. What is the distribution over time of the publications included in this review? What are the main applications indicated for these tools?

Identification and Search for Studies (Databases)

To achieve the research objective, a single search string was used in both databases. The search string

utilized was: “New educational technologies” OR “ICTs” OR “Educational technological tools”. No limitations on publication date were applied.

Data Extraction and Synthesis (Selection Process)

In the operationalization of the search, after identifying the articles based on titles and/or abstracts, they were imported into a Word file to identify any duplicity. For the selection of articles, the following inclusion criteria were considered: regarding language, studies in Portuguese, English, and Spanish were accepted; concerning the type of scientific production, articles published in specialized scientific journals were included; there were no restrictions regarding the type of research; there were no restrictions regarding the sample; inherent to the objectives of the studies and the results presented, articles related to ICT tools used to support teaching and learning at different educational levels were accepted; regarding access, articles with open access were accepted.

Screening of Included Studies

The selection of publications included in the search was conducted independently, based on pre-defined inclusion and exclusion criteria. Relevant data were extracted from the included studies and organized into tables to facilitate comparative analysis.

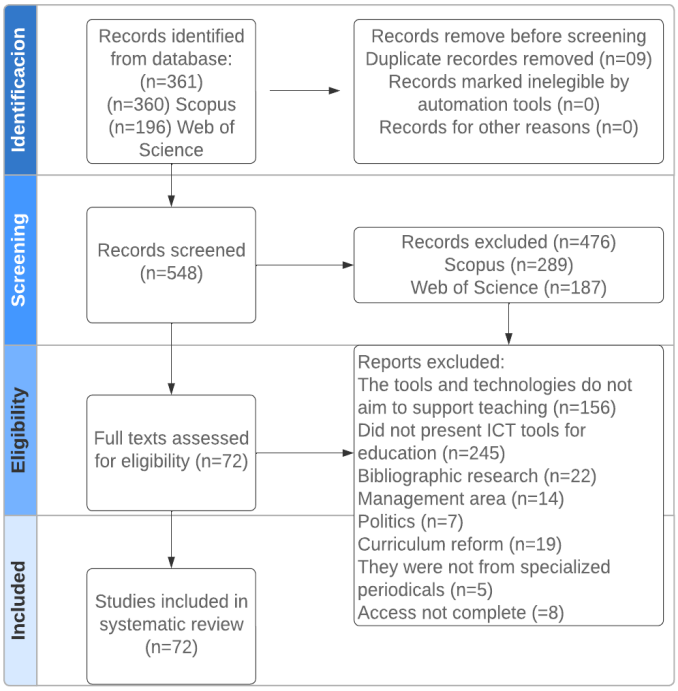

Figure 1. The screening procedure based on the PRISMA 2020 model.
Source: elaborated by the author.

Analysis of Results

For the interpretation of results, the software the Jamovi Project (2023), version 2.4, was utilized, aiding in descriptive statistics and the creation of tables and graphs. The identified tools and technologies were grouped into categories such as online learning platforms, educational apps, virtual learning environments, among others, to identify patterns and emerging trends. This involved describing the identified tools and technologies, highlighting their characteristics, functionalities, and potential applications in supporting teaching. It culminated in a discussion of the main findings and implications for educational practice.

Results

The data presented in Table 1 allow us to observe that as a result of the searches in the databases, 361 studies were found in Scopus and 196 in WoS, totaling 557 publications in the databases (TPB). Out of this total, 64 in Scopus (ACI Scopus) and 25 in WoS (ACI WoS) met the inclusion criteria (ACI); 289 in Scopus (NCI Scopus) and 170 in WoS (NCI WoS) did not meet the inclusion criteria (NCI); eight (8) in Scopus (Rep Scopus) and one (1) in WoS (Rep WoS) were duplicates within their respective databases; 17 met the inclusion criteria and were duplicates in both databases (ACI Rep), and 64 did not meet the inclusion criteria and were duplicates in both databases (NCI Rep).

Table 1

Descriptive Statistics

Publication type	WoS	Scopus	ACI-WoS	ACI-Scopus	NCI-WoS	NCI-Scopus	Rep WoS	Rep Scopus	ACI Rep	NCI Rep	TPB	TPI
Article	66	206	13	32	53	174	1	6	10	43	272	34
CP	123	116	12	26	111	90	0	2	7	20	239	32
Review	3	7	0	1	3	6	0	0	0	1	10	1
MA	1	0	0	0	1	0	0	0	0	0	1	0
BC	2	29	0	5	2	24	0	0	0	0	31	5
Book	1	3	0	0	1	3	0	0	0	0	4	0
Total	196	361	25	64	171	297	1	8	17	64	557	72

Source: survey data.

Regarding the type of study, the TPB consisted of 272 articles, 239 conference papers (CP), 10 reviews, 31 book chapters (BC), four (4) books, and one (1) meeting abstract (MA), comprising the 557 publications analyzed and presented in Figure 2. The significant percentage of scientific articles comprising the search results in both databases (48% of articles and 42% of CP) points to a considerable academic relevance of the research subject of the present study, notably drawing the attention of researchers and indicating it as a current problem of scientific investigation.

The temporal variation of the documents found covers the interstice from 1962 to 2024, as can be seen in Figure 3, which points to a growth trend, over the years, in studies with a theme related to the research string used here.

After completing all search and screening stages, 72 (seventy-two) publications were included in the Total of Publications that met the inclusion criteria (TPI), making up 12.9% of the 557 registered in the TPB. The TPI contains 34 articles, 32 CP, five (5) BC, and one (1) review, data that are corroborated in Figure 4.

Aiming to answer the research questions, specific and relevant data were categorized within the TPI for meeting the inclusion criteria. These criteria encompass the identification of technological tools, strategies, and educational applications. To support data extraction and analysis, we followed the subsequent steps: individual reading of the selected articles, categorization according to the type of tools, collaborative discussion to define the references and grouping of technological tools, with the results presented in Table 2.

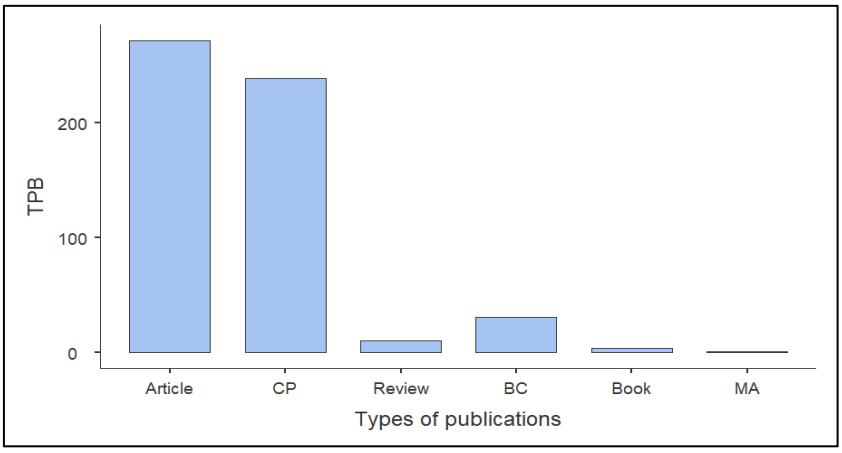

Figure 2. Types of publications on TPB.
Source: elaborated by the author.

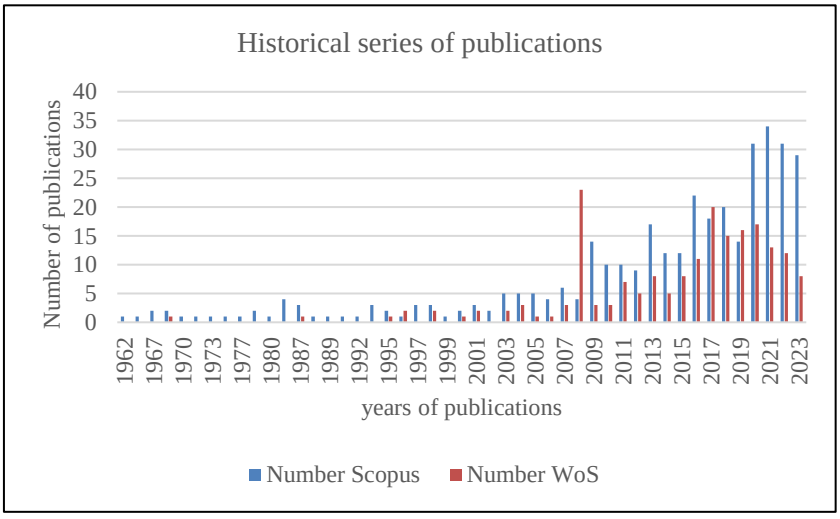

Figure 3. Number of publications per year (1962-2024).
Source: elaborated by the author.

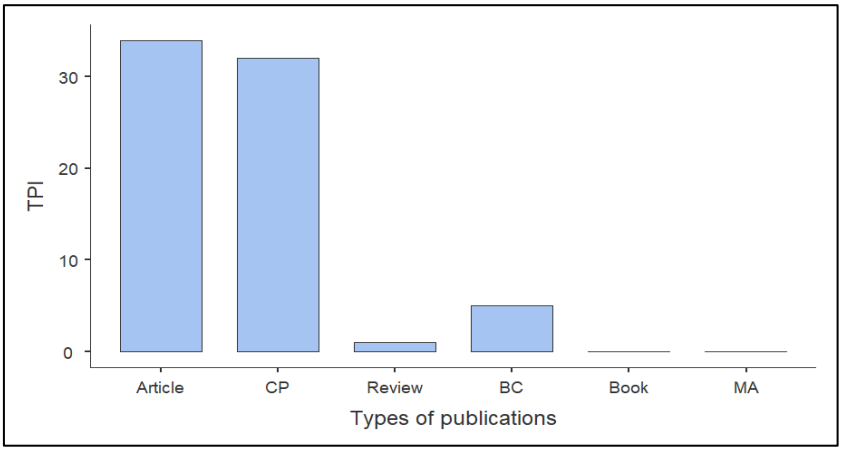

Figure 4. Total and types of publications that met the inclusion criteria.
Source: elaborated by the author.

Table 2

Technological Tools to Support Teaching and Their Applications

Amount	Tools	Studies	Applications
5	Virtual reality; 360 °video, metaverse	Du (2021), Khoshnoodifar et al. (2024), Mentsiev et al. (2023), Tito, Basso, & Moraes (2022), Suh & Ahn (2022)	Student involvement Visual learning Professional skills Immersive virtual environment Interaction with avatars
5	Augmented reality; animations	Rodriguez-Abad et al. (2021), Kearney et al. (2020), Lehto et al. (2020), Craciun et al. (2017). Salmi et al. (2010)	Multidimensional influence for guided learning Digitization of product dissection Educational content creation Boosting physics teaching
6	Gamification; virtual educational games; Education; MMOGs (Massive Multiplayer Online Games)	Delgado (2023), Sokolova & Deviantnikova (2023), Kovács (2021), Roper et al. (2019), Mysirlaki & Paraskeva (2010), Seliutin (2019)	Meaningful learning Teacher training Student motivation Collaborative learning Ludonarrative Increased communication and interaction Improved team cooperation
11	E-learning platforms, AVA, Moodle, WeChat, Rain Classroom, Web, Conference, Live-webinar, Workshop, online discussion forum, M-Learning, Web-Quest, E-portfolio, Online-Diary, CoAST Software	Alam et al. (2023), Xue et al. (2023), Zou et al. (2022), Shardlow et al. (2022), Akbari (2021), Jena (2021), Bazarnova (2020), Zhong (2018), Voronova (2018), Baruah (2018), Castro (2014)	E-feedback Learning improvement Massive open online courses (MOOCs) Democratization of education Emotional and academic interaction and collaboration Organization and self-organization of educational activities Self-learning Text comprehension
7	Communication platforms (Zoom, Hangouts, Teams, Skype, Moodle, among others) and social networks (Viber, Skype, WhatsApp, etc.)	Da Costa (2023), Akbari (2021), Gadakchyan (2020), Bagarukayo (2017), Zekanović (2010), Len et al. (2009), Homanova et al. (2018)	Innovation and creativity in the selection of content and teaching methods Content interaction and practical learning Student autonomy Online engagement Collaborative skills
2	Blackboard Learn Educreations™	Al Mansoori (2022), Ahmad & Hinck (2016)	Learning management system Educational content creation
6	Artificial intelligence (AI); ChatGPT; 5G+AI; STEM AI, LUMILO	Wang & Guo (2023), Kshirsagar et al. (2022), Zhao (2022), Joshi et al. (2021), Yannier et al. (2020), Holstein et al. (2019)	Improvement of the teaching-learning process Knowledge sharing Educational effectiveness Co-design Development of educational technologies
2	Mind mapping technology; Mathematical Expression Map System	Murugova & Verbovataya (2022), Rugh et al. (2021)	Visual-figurative, psycholinguistic thinking Self-guided learning
3	Educational kit 2S-CACSET Ultra-Wide Band (UWB) 2D Dashboard Graphic interface Hypertext Digital history	Nava-Pintor et al. (2021), Pirozhkova (2021). Szafnicki & Michau (2000)	Learning from prototypes Language learning Environmental adaptation Non-linear content navigation and exploration
4	Robotic Platform; Educational Robots; Hypermedia; Robotic Theater; LEGO Robotics	Ajlouni & Jaradat (2021), Tobar et al (2021), Zaldivar et al. (2017), Jang & Yosephine (2016)	Understanding scientific concepts Child education
4	Virtual simulators and interactivity Real Experiment eXecution (REX) approach	Matokhina et al. (2019), Gomez et al. (2009), Chirico et al. (1997), Amend et al. (1986)	Prototyping Advancement of astronomy teaching Continuous learning and adaptation Education systems management

Table 2 to be continued

2	Educational technology "Re-Foresight"	Shinina & Morozova (2018), Sergeevna (2021)	Prospective methodology Future review or reassessment Scenario analysis for practical learning
8	Multimedia (audio, video, text, graphics and animation) iPad Video classes Video games	Zakharova et al. (2022), Kourova (2020), Lin et al. (2017), Kemal et al. (2016), Camacho (2013), Komlenović et al. (2013), McKenzie (2008), Margolis et al. (2006)	Blended learning Self-learning with intercultural connectivity Skills development Learning in languages and mathematics
3	Virtual laboratory	Gostev & Mosin (2018), Ottaviano et al. (2018), Shidlovskiy et al. (2003)	Creation of educational routes and technologies Reproduction of informational structure Innovation in teaching
1	Signals—data mining	Tanes et al. (2011)	Data mining and academic success
2	Moblogging Weblogs	Lee (2007), Turner & Usher (2005)	Real-time knowledge bridge Sustainable and scalable use of educational technologies
1	Microsoft family, pearltress, prezzi, spicynodes. Interactive e-books; Apple's iBooks Author tool	González et al. (2015)	Interactivity and improvement of the teaching-learning process

Source: survey data.

Discussion

Conducting the systematic review allowed the identification and analysis of a wide range of emerging tools and technologies in the context of education, with a focus on facilitating teaching, adapting to education 4.0 paradigms and optimizing the teaching-learning process. This scenario reflects the significant interest of the academic community in the integration of educational technological solutions, showing a close correlation with approaches aimed at solving educational challenges in all their stages, in line with the observations of previous systematic reviews carried out by Lai and Bower (2020) and Lu and Xie (2023). Furthermore, it is worth highlighting the fact that we observed in the research included in this study the search to promote the development of digital skills among teachers, this being a recurring objective in the process of designing and implementing these tools, corroborating the conclusions outlined by Alférez-Pastor et al. (2023).

Examining the time interval (2019-2022) represented in Figure 2, it becomes imperative to highlight the notable increase in the volume of publications related to the research topic. This increase suggests the possible influence of the COVID-19 pandemic, as evidenced by the selected studies corresponding to this period, which reflect the urgent demand in the educational context and the impacts of the confinement imposed at that time (Akbari, 2021; Alférez-Pastor et al., 2023; S. Jena & P. Jena, 2021; Tobar, Prócel, López, Bacca, & Caicedo, 2021).

While the increase in academic interest in research production in this area is understandable, a substantial proportion of studies document the difficulties faced by students and teachers when dealing with new information and communication technologies (ICTs), due to their complexities and the specific competencies and skills required. In this context, recommendations stand out for the implementation of training programs and the inclusion of these topics in teacher education curricula, aiming to mitigate barriers to the use of technologies in education and thus encourage collaborative learning and peer interaction (Delgado, Mendes, Brocardo, & Boavida, 2023; Kovács, Szilágyi, & Várallyai, 2021; Mysirlaki & Paraskeva, 2010; Roper, Millen Dutka, Cobb, & Patel, 2019; Seliutin, 2019; Sokolova & Deviatnikova, 2023). However, it is important to emphasize that the development of digital competence among educators requires a comprehensive intervention program that is not limited only to future teachers but also includes those already involved in educational practice (Alférez-Pastor et al., 2023).

Inherent to the information and communication tools presented in the studies compiled in Table 2, e-learning platforms, online communication tools, and multimedia emerge as more established areas of research, possibly due to their support in elements such as electronic feedback, positive reinforcement, emotional and academic interaction and collaboration, self-learning, online engagement, and hybrid teaching models. In the same context, there is a growing interest in studies seeking to understand the educational impacts of artificial intelligence (AI), virtual and augmented reality (VAR), gamification, digital games, and the metaverse. This trend reflects a commitment to the development of problem-solving skills (Lu & Xie, 2023) and is supported by a series of recent studies (Delgado et al., 2023; Kearney, Starkey, & Miller, 2020; Khoshnoodifar, Emadi, Mosalanejad, Maghsoodzadeh, & Shokrpour, 2024; Lehto, Lautkankare, Brander, Ala-Nissilä, Saari, & Salminen, 2020; Mentsiev et al., 2023; Rodriguez-Abad, Fernández-de-la-Iglesia, Martinez-Santos, & Rodriguez-Gonzalez, 2021; Roper, Millen Dutka, Cobb, & Patel, 2019; Tito, Basso, & Moraes, 2022).

Therefore, as a synthesis of the main conclusions, it is observed that there is currently a wide range of tools and ICTs applied in the educational context, with particular emphasis on AI, VR, and gamification, which stand out as prominent trends for improvements in subsequent studies, as evidenced by the temporal analysis conducted in this systematic review. In addition to this scope, the already consolidated e-learning platforms, virtual learning environments (VLEs), and social networks are also aligned.

In line with the specific purposes and applications of each mentioned technology, there is a focus on improving and enhancing the teaching-learning process, creating immersive virtual environments, promoting meaningful learning, fostering student autonomy, providing ongoing teacher training, developing collaborative skills, facilitating self-directed learning, and even innovating in the conception of new technologies.

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