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PAPER

Role of Augmented Reality, Virtual Reality and Streaming Services in the Field of Education (2020–2023) – A Systematic Review

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ABSTRACT

This paper systematically reviews the demand for real-time streaming services in the education sector over the period 2020–2023. The systematic review analyzes the effects of augmented reality (AR) and virtual reality (VR) in education, focusing on the need for real-time streaming services. These technologies have grown significantly in education, enabling collaborative and immersive experiences. VR, supported by leading streaming platforms, has facilitated distance education, especially during the COVID-19 pandemic. The methodology was based on searching for articles in databases such as Ebsco, Springer, IEEE, ScienceDirect, and Scopus. Inclusion and exclusion criteria were applied, creating a final sample of 60 papers, with a geographical distribution highlighting the important role of China and the United States. The results indicate that changes in education, the focus on VR, and the impact of the COVID-19 pandemic are the main drivers of demand for educational streaming. This led to a rapid adoption of online educational platforms. Challenges to implementing streaming services include a lack of training in educational institutions and a lack of practice in certain areas. Content customization, video quality, and adequate technological infrastructure are the most sought-after functionalities by users.

KEYWORDS

virtual reality (VR), education, online classes, training, streaming applications

1 INTRODUCTION

Augmented reality (AR) and virtual reality (VR) are two of the most prominent technological innovations in the education sector today and have great potential to transform the education system. The use of AR and VR in education has increased significantly in recent years and offers a variety of opportunities to enhance learning through technology [1]. Indeed, educators are keen to include computer applications in their curricula [2]. AR and virtuality complement traditional teaching and

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open new doors to more personalized and dynamic educational methods as society moves toward an increasingly digital future. [3] This shift towards more experiential and collaborative education promises to improve knowledge retention and develop vital 21st-century skills such as creativity, problem-solving, and collaboration. This analysis of the possibilities of AR and VR in education shows a promising future where technology can change education [4].

Virtual reality allows users to experience an immersive experience through a multi-dimensional screen, allowing them to explore changing perspectives at will. Facebook, YouTube, Zoom, Google, Microsoft, Amazon, and other well-known companies have created platforms to offer virtual reality services, generating great interest worldwide [5], [6]. The proliferation of web conferencing services has enabled real-time communication between remotely located students and teachers, supporting voice communication via voice over IP, live webcam streams, and multimedia content sharing [7], [8]. These technological services have increased student engagement and promoted virtual learning environments (VLE) as an effective alternative to face-to-face teaching [9], [10]. VR applications have complemented or, in some cases, replaced traditional teaching methods such as lectures, hands-on lab sessions, and textbooks [11]. The rapid spread of COVID-19 led to the closure of universities, prompting an accelerated transition from face-to-face to online education. Numerous benefits of distance learning have been noted, including ensuring educational continuity [12] and promoting lifelong learning [13], underlining the disruptive potential of educational tools, as discussed [14].

The success of these technologies depends largely on how they are perceived by teachers and their ability to adapt to their goals, teaching strategies, and expectations [15], [16]. Previous tools, such as Web 2.0 and Web 3.0, have exemplified this approach [17]. A crucial component of the VR learning experience is using VLEs, which resemble shared spaces or virtual worlds in which teachers and students exercise significant control over 3D avatars. Research on multi-user VLEs and avatar representation has also highlighted increased participation and performance [18], [19]. When combined with poor interaction and navigation design, these challenges can result in substandard learning and training experiences in virtual reality.

While many studies have explored the adoption of technologies such as VR and AR in the education sector, this paper focuses on analyzing specifically the demand for streaming services as a means of implementing these technologies. Unlike previous studies that have focused on the pedagogical effectiveness of VR and AR in controlled environments, this paper examines the practical infrastructure challenges and technological needs of real-time streaming in a widely distributed educational context.

Based on the literature review, this study analyzes the impact of AR and VR in education, highlighting the growing interest of educators in these technologies. It discusses how VR, through the platforms of major streaming service companies, has facilitated distance communication and influenced the transition to online education, especially during the COVID-19 pandemic. It also examines how VR has changed or replaced traditional educational methods, highlighting the benefits and challenges, with an emphasis on teachers' perceptions and adaptations. To this end, the following research questions were posed:

RQ1. What is the evolution of demand for real-time streaming services in the education sector in the period 2020–2023, and what are the key factors influencing this trend?

RQ2. What is the impact of the COVID-19 pandemic on the demand and adoption of real-time streaming services in the education sector over the period?

What are the most common challenges faced by educational institutions in implementing and using real-time streaming services, and how have these challenges evolved from 2020 to 2023?

2 LITERATURE REVIEW

This section presents related work, which addresses important factors such as student motivation in virtual education as a critical factor influencing learning success. Also, other work suggests that tools such as VR and AR, enabled through streaming services, can significantly increase student engagement by providing interactive and personalized experiences. This is crucial, as higher motivation is associated with better academic results and lower dropout rates. For example, in [20], an attempt was made to use social networks to sustain medical education. Social networks play an important role in providing immediate access to high-quality content. Recognizing that these platforms cannot completely replace face-to-face teaching is important. Combining face-to-face and digital methods is crucial to ensure comprehensive and effective medical education in the future. In addition, [21] analyzed the effects of virtual education, focusing on the concept of "biopower" and control techniques, such as the need to use cameras. It emphasizes the importance of considering the use of these tools to maintain students' independence. In addition, he offers a critical perspective on the digital transformation in education, emphasizing a student-centered approach.

2.1 Effects of the pandemic on education and technology

In this section, the effects of the pandemic on education and technology are highlighted. For example, in [22], the REP-ACAD-COVID-19-LAT scale was validated to assess the academic impact on Latin American students during the pandemic. The tool showed high reliability ($\alpha = 0.915$) and a unidimensional model that explained 70.44% of the variance. The validation involving students from several countries supports its usefulness in public health crises. In addition, ref. [23] emphasizes the relevance of e-learning in higher education, particularly in flexible environments. Good practices were implemented in a master's Information and Communication Technology course, generating positive outcomes for the instructor and the ten participating students. This approach highlights the effectiveness of virtual education in academic contexts, underlining its potential to enhance the learning experience in higher education. Also, in [24], students' perceptions of post-quarantine virtual classes at a business school in Bogota were evaluated. It was found that there was an improvement in the perception of high quality, with a positive relationship between satisfaction and the intention to continue with this methodology. These results suggest the viability and acceptance of virtual classes in the educational environment. In addition, a survey of 501 urology residents from 58 countries was conducted in [25] to evaluate e-learning during the pandemic. Most pre-recorded videos, interactive webinars, podcasts, and social networking sites are very useful, underlining the importance of these modalities in current and future medical education. Finally, in [26], an annual bereavement event was successfully adapted to a virtual format, which was well received by participants. The virtual events showed comparable attendance rates to the face-to-face events, with a higher international representation.

2.2 Application of specific technologies in education

In this section, the application of specific technologies in education is highlighted. As illustrated in ref. [27], where a scientific analysis of VR in medical education (2012–2021) revealed an increase in publications, especially in high-impact journals, with notable contributions from countries such as the USA. The growing international collaboration underlines the importance of VR in medical education. The results obtained reflect a growing interest and relevance of VR in the educational and medical fields worldwide. [28] examined the use of virtual lectures in plastic surgery following the COVID-19 outbreak. It was found that 35.4% of attendees used them daily and 51.4% of presenters used them weekly, highlighting their potential as an educational tool in this field. Finally, [29] evaluated the feasibility of virtual "Mock Trials" in pharmacy programs during the pandemic. Teachers and students evaluated its operation positively, highlighting the usefulness and ease of use of videoconferencing technology.

3 METHODOLOGY

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology is used for the elaboration of this work. The PRISMA statement provides a structure that serves as a guide for a more orderly and clear development. It details the steps of the PRISMA method, such as identifying related documents important to the topic, excluding duplicate documents, eligibility analysis is developed [30].

A systematic literature review is conducted to assess the current impact of AR and VR in online education. The technique seeks to identify trends in streaming services by collecting and analyzing studies, reviews, and academic works [31]. The systematic review uses a methodical and transparent approach to locate, select, and critically evaluate relevant literature in a specific area on the current use of VR in education, assessing experiences, opinions, and perceived challenges. This method provides a detailed and direct understanding of experiences in education, allowing for an accurate assessment of the impact of VR on education [32].

For the present study, a comprehensive collection of articles related to the demand for real-time streaming, AR, and VR services in the education sector from 2020 to 2023 was conducted. The parameters set out in the PRISMA methodology guided this collection process.

Consideration of the following elements determined the inclusion of these articles in the systematic review:

- The presence of terms related to the demand for streaming services in online education, VR, and AR ensures a direct connection between the articles found and the focus of this systematic review.
- Writing in English, as it will provide wider access to international information relevant to the aspects addressed in this systematic review.
- Articles published between 2020 and 2023, as this period ensures that up-to-date information relevant to the topic of interest is obtained.
- Sourced from highly reliable databases, guaranteeing a solid and accurate review of these articles.

To eliminate the articles, the following aspects have been considered:

- Duplicate articles were removed to avoid repetition of information.
- Articles unrelated to the demand for streaming, VR, and AR services in online education were excluded.

- Articles that do not address the research questions posed were discarded.
- Articles with insufficient information were eliminated.

The following databases were considered for the search process: IEEE, ScienceDirect, Scopus, Springer, and EBSCO.

The articles included in the systematic review had the following distribution:

As a first step, a search was carried out using keywords such as “virtual AND education AND online AND Streaming AND services,” as well as their equivalents in Spanish, “virtual y educación y en línea y Streaming y servicios.” Subsequently, a year of publication filter was applied, considering only those documents published between 2020 and 2023 for the research.

The situation described above led to the inclusion of 400 articles and 77 conferences in the “papers” category. These were selected after applying filtering criteria that included relevance to this systematic review’s study objective and the presence of keywords in the title related to the demand for real-time streaming services in the education sector during the period 2020 to 2023.

The papers in the systematic review had the following distribution, as shown in Figure 1

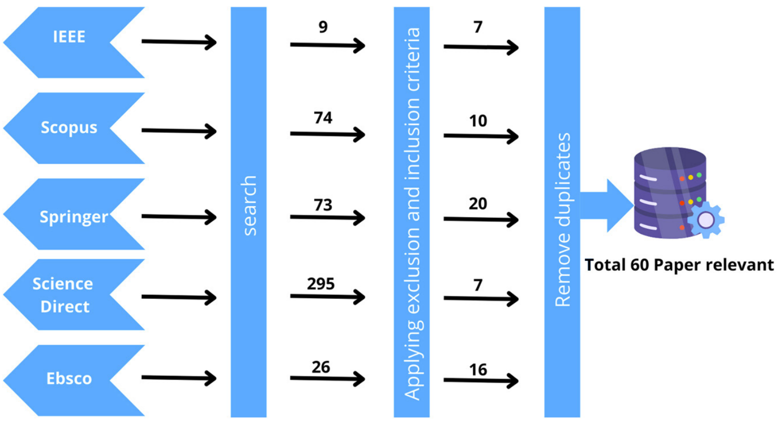

Fig. 1. Number of studies identified by each database

To conclude, a duplicate check was carried out using the Mendeley tool to identify possible duplicate articles. Subsequently, articles were downloaded from each database in XML format, allowing further filtering in Microsoft Excel. Figure 2 shows the specific quantities found during the search for information in the databases, following the parameters of the PRISMA methodology.

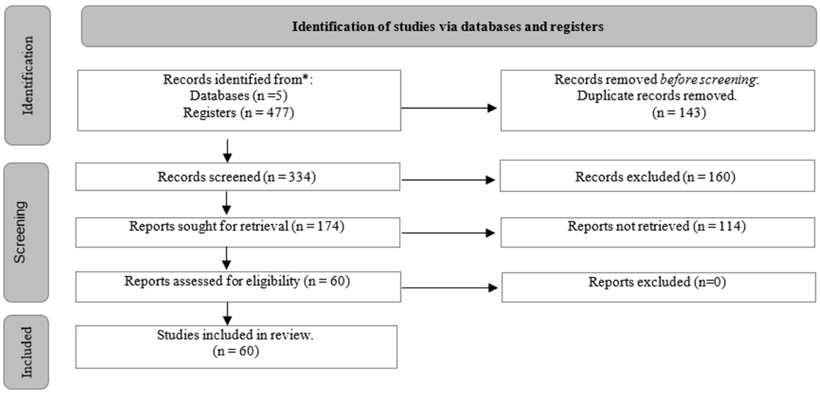

Fig. 2. PRISMA methodology

4 RESULTS

The findings were structured based on a database of 477 research studies. After a rigorous analysis of the established filters, a methodological database with 60 research studies was created. The literature review aimed to explain how and what results were obtained by using the PRISMA method as shown in Figure 2. Starting by listing multiple bibliographic databases, including ScienceDirect, Scopus, IEEE, Ebsco, and Springer. The first stage, identification, consisted of an initial selection based on keyword and key phrase searches. 477 records were obtained, 23.27% from ScienceDirect, 14.87% from Scopus, 10.66% from IEEE Xplore, 30% from Ebsco, and 31.20% from Springer.

In the second stage, in the show block, using the second selection criterion, considering the year of publication, 334 studies were found, in this case from 2020 to 2023, where 20.93% of the publications are represented by ScienceDirect, 6.30% by Ebsco, 13.52% by IEEE Xplore, 35.01% by Scopus, and 22.15% by Springer.

The third phase of eligibility consisted of 114 excluded and 174 selected papers with titles containing words or phrases related to the topic of the current systematic review. The results included 29.48% in ScienceDirect, 1.40% in EBSCO, 17.59% in IEEE Xplore, 28% in Scopus, and 23.52% in Springer.

Finally, in the fourth phase, 114 documents were incorporated, including the criterion of reading the abstract, in which identification is applied by components such as the methodology and the results found. This allows clarifying the relevance of the study and its relationship with the objective of the study. It is considered that it has the same unit of analysis and variables or constructs addressed and the correct access link.

Of the latter, 7 (12%) were from Science Direct, 16 (27%) from EBSCO, 7 (11%) from IEEE Xplore, 10 (17%) from Scopus, and 20 (33%) from Springer. As shown in Figure 3.

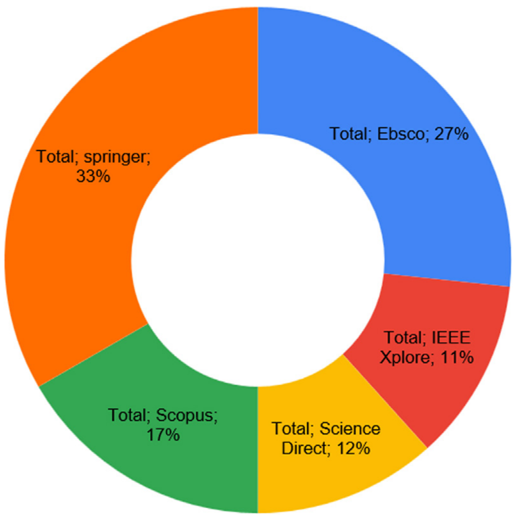

Fig. 3. Percentage data from the database

Figure 4 shows the distribution of documents in the research according to their year of publication, spanning from 2020 to 2023. A steady growth is evident in the number of recent papers. In 2020, they accounted for 15% of the total; in 2021, 23%; in 2022, 37%; and in 2023, 25%. This gives a total of 60 documents added to the research.

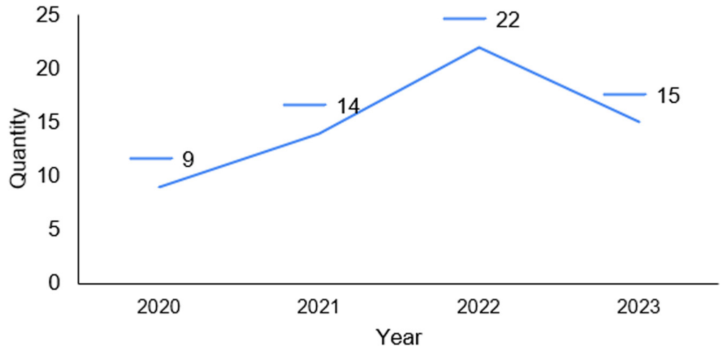

Fig. 4. Documents included in the research according to the year of publication

The distribution of documents by country of origin is detailed below. China leads in representation with 28% of the total, equivalent to 17 documents, suggesting a significant contribution to this research. It is followed by the United States with 25% and 15 documents, Australia and India together with 14% and 14 documents, Canada with 5% and three documents, Greece, the United Kingdom, Taiwan, and Korea together with 12% and eight documents, Austria, Brazil, Germany, Korea, Ecuador, Indonesia, Iran, Qatar, Russia, and Sweden together with 20% and ten documents, showing their relevance in this project. This makes a total of 18 countries and 60 documents. These results are presented in Figure 5.

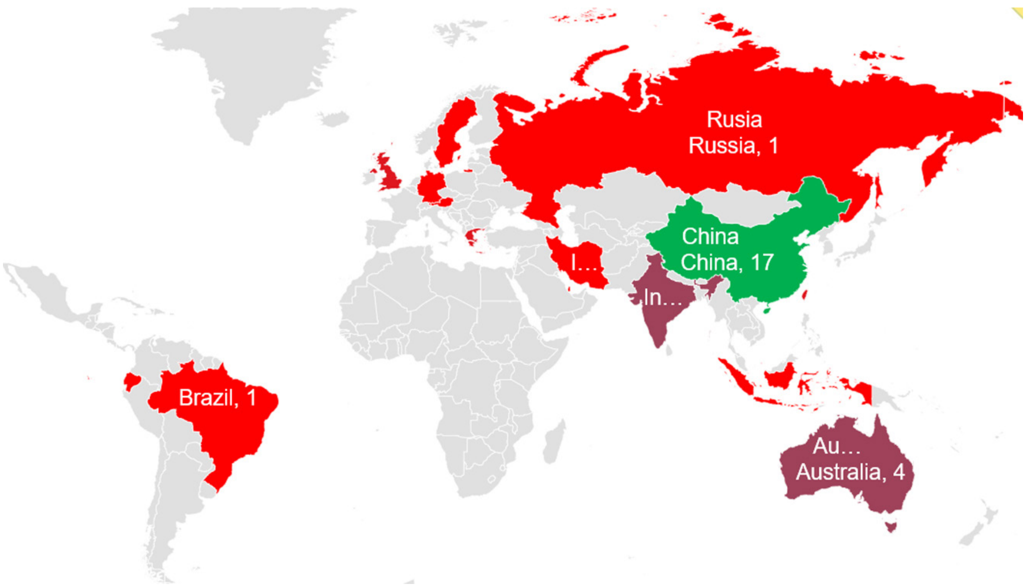

Fig. 5. Documents included in the research according to country of origin grouped by continent

Identifying the type of manuscripts between lectures and original articles was also possible. Lectures represent 5%, and original articles account for 95%.

On the other hand, the articles were distributed in the five academic databases, classified into "Quantitative" and "Qualitative." In total, 48% of the articles are quantitative, while 52% focus on qualitative research. Specifically, Springer leads with 17% of quantitative and 17% of qualitative articles, followed by EBSCO with 11% and 15%, respectively. ScienceDirect has 10% quantitative and 2% qualitative articles, Scopus has 5% quantitative and 11% qualitative articles, and IEEE has 5% quantitative and 7% qualitative articles.

5 DISCUSSIONS

This section seeks to answer each of the research questions.

5.1 RQ1: What is the evolution of demand for real-time streaming services in the education sector over 2020–2023, and what are the key factors influencing this trend?

The most common challenges identified include insufficient bandwidth, limited connectivity, and lack of teacher training. These results are consistent with the findings of [25], who noted that inadequate technological infrastructure affects the quality of real-time broadcasts. Also, in the work [26], they highlighted the lack of initial interactivity on the platforms, which influences student motivation. It also correlates with the findings of the paper [20], where they applied AI and deep learning techniques in teaching and learning, such as intelligent tutoring systems, VR, and educational data mining. Similarly, it relates to the paper [28], where they conducted a comprehensive analysis of VR in medical education between 2012 and 2021. Here they highlight an increase in high-impact publications, underlining international collaboration and the global importance of VR in medical education and practice.

However, the results also show important advances in the evolution of these challenges such as the incorporation of interactive features from previous studies. This work underlines that overcoming these barriers is still an evolving process, with incremental improvements, but still insufficient in many educational contexts. Table 1 presents the factors influencing the trend in demand for streaming services.

Table 1. Factors influencing the trend in demand for streaming services

#	Factors Influencing the Trend in Demand for Streaming Services	References
1	Impact of streaming on education	[36] [37]
2	Impact of technology and evolution of streaming	[38] [39] [40]
3	Connectivity and participation	[41] [42] [43]
4	Demand and change in education	[44] [45] [46] [47] [48] [49] [50]
5	Focus on virtual realities	[51] [52] [35]
6	Importance of online education	[53]
7	Exponential and technological growth	[54] [55] [56]
8	Interaction in learning systems	[57]
9	Accelerating the adoption of e-learning platforms during the COVID-19 crisis	[58]
10	Key impact of pandemic on demand for streaming services	[59] [60]
11	The rapid adoption of digital technology by universities during the pandemic	[61]
12	Streaming quality, content customization, and technology infrastructure	[62]

5.2 RQ2: What is the impact of the COVID-19 pandemic on the demand for and adoption of real-time streaming services in education during the period under review?

The impact of the COVID-19 pandemic was a critical catalyst in the adoption of streaming platforms to ensure educational continuity. This finding is supported by work [22] which documented that virtuality enabled the mitigation of educational disruptions during the health crisis. In addition, studies such as [25] and [29] highlighted the acceptance of virtual environments, although they identified the need for teacher training to maximize their use.

In comparison, the findings in this article specifically highlight how the pandemic drove the transition to hybrid learning, an aspect less explored in the literature review; persistent challenges, such as teacher training and technological infrastructure, remain significant barriers. This analysis highlights the need to further strengthen technological capabilities and integrate immersive technologies such as AR and VR in education. Table 2 presents the adoption of real-time streaming services in education.

Table 2. Adoption of real-time streaming services in education

#	Impact of COVID-19 on Streaming Demand and Adoption	References
1	Raising awareness of the importance of technology in education	[36] [63] [40]
2	Implementation and training challenges for educational institutions	[64]
3	Urgent implementation of online education modalities	[65]
4	The exponential increase in demand for distance education streaming services	[66] [67]
5	Threats and revelation of shortcomings in teaching in practical fields	[68]
6	Increase in screen-mediated reading as a family adaptation	[69]
7	The rapid increase in the adoption of corporate cloud-based education solutions	[70]
8	Significant impact on post-secondary life driving mass adoption of online learning platforms	[58]
9	Rapid response to online education and research through digital technology	[61]
10	Drive to support and provide opportunities for online skills development	[71]
11	Rapid virtualization and the need for evaluation of curriculum redesign due to disruption of work placements	[72]
12	Remote education as reality during a pandemic	[73]
13	Education transformation amid the global COVID-19 crisis	[62]

5.3 RQ3: What are the most common challenges educational institutions face when implementing and using real-time streaming services, and how have these challenges evolved from 2020 to 2023?

The results show a significant growth in demand for streaming services, influenced by factors such as the COVID-19 pandemic, the advancement of immersive technologies such as AR, VR, and the need for remote learning. This finding aligns with that mentioned in [27], which highlighted that these technologies enable more personalized and collaborative experiences in education. Furthermore, [24] highlights the role of AR and VR in enriching teaching in practical areas.

On the other hand, the technological challenges faced by educational institutions when implementing these streaming services, such as the lack of infrastructure and connectivity, coincide with the findings of [23], which emphasized the importance of having broadband connectivity to manage real-time streaming traffic. However, this paper provides more up-to-date perspectives by demonstrating how platforms have begun to overcome these limitations, especially in contexts of high educational demand. Also, it correlates with [21], where they argue that real-time streaming requires considerable bandwidth, so the network infrastructure of some institutions is not robust enough.

Finally, it can be concluded that insufficient bandwidth and connectivity problems, which are recurrent in educational institutions, underline the urgent need to strengthen the network infrastructure. These challenges highlight the crucial importance of improving real-time transmission capacity to ensure the successful deployment of educational streaming services. Table 3 presents the most common challenges when implementing streaming services.

Table 3. Common challenges when implementing streaming services

#	Common Challenges When Implementing Streaming Services	References
1	Technology Evolution: AI and VR present challenges and opportunities.	[64]
2	Insufficient Bandwidth in 2020: Institutions addressed real-time streaming load through upgrades and expansion of network capabilities.	[39] [72]
3	Lack of Initial Interactivity: Challenge overcome with the evolution of platforms, integrating interactive features to improve student engagement.	[75]
4	Diversity of Devices and Operating Systems in 2020: Compatibility challenges overcome with more flexible and accessible platforms.	[76]
5	Real-time Audio and Video Synchronization: The initial challenge was solved with technology enhancements for a higher-quality broadcast experience.	[77]
6	Network Infrastructure Challenges: Real-time streaming requires robust infrastructure; problems can affect quality and cause delays.	[51]
7	Poor Connectivity in 2020 and Improvements: The initial challenge was limited internet access areas; improvements and strategies were adopted.	[78]
8	Student Motivation in Virtual Environments: The challenge addressed with evolved platforms that include interactive features and methods of participation.	[79]
9	VR 360° Technology Challenges in Education: Generating large volumes of data requires increased coding and storage capacity.	[80]
10	Network Infrastructure Challenges for Real-Time Video: Infrastructure efficiency is needed to handle large traffic volumes, adopt 5G technologies, and optimize bandwidth.	[55]
11	Challenges in Knowledge Tracing (KT): Unclear correspondence between variables and concepts and binary variables may not accurately reflect the learning process.	[46]
12	Challenges in Digital Educational Evolution: Resilience to challenges, highlighting security, student participation, and technological flexibility.	[81] [82]
13	Adaptation in Early Childhood: Re-imagining socio-cultural relationships and adapting to digital environments, a challenge for educators.	[49]
14	Practical Teaching Effectiveness: Challenge in practical fields, such as product design, during the pandemic.	[68]
15	Technology Gap in Distance Learning: Challenges in adapting to the new reality, impacting the adoption of educational technologies.	[70]
16	Challenges in Applied Education: The Pandemic creates logistical and technological challenges in integrating VR, AR, and RM to maintain effectiveness.	[83]

(Continued)

Table 3. Common challenges when implementing streaming services *(Continued)*

#	Common Challenges When Implementing Streaming Services	References
17	Parental Challenges during Pandemic: Adapting to work-family balance and finding online educational resources.	[84]
18	Challenges in Online Learning: Lack of interaction, delayed feedback, and shorter learning and communication times.	[85]
19	Challenges in Virtual Environments and Social Networks: Technological adaptation, privacy, data security and the need for teacher training.	[86]
20	Technical and Skills Challenges for Teachers in Hybrid Scenario: Adaptation to new technologies, software selection, and teacher training.	[87]
21	Evolving Challenges in the Implementation of Streaming Services: Evaluating efficiency in overcoming digital barriers.	[88] [89] [50] [90] [91]

6 CONCLUSION

This paper provided a comprehensive analysis of the role and evolution of demand for streaming services in the education sector between 2020 and 2023, focusing on the impact of immersive technologies such as AR and VR. The objectives of this research have been met by answering the three questions posed and providing a comprehensive view of the factors driving this trend, as well as the associated challenges. To this end, 60 articles out of 477 were analyzed; inclusion was based on criteria such as abstract, relevance to the objective, and accessibility through links. Springer was the most representative source with 33%. The geographical distribution highlights the important contribution of China (28%) and the United States (25%). The annual evolution shows a steady increase, reaching 25% in 2023. The majority of the documents (95%) are original articles, with a balance between quantitative and qualitative approaches.

With this, it was identified that the COVID-19 pandemic acted as a key driver for the adoption of streaming services, accelerating the transition towards remote and hybrid learning environments. The integration of technologies such as AR and VR into educational platforms has enabled more immersive and collaborative experiences, which has significantly increased interest in these technologies. However, this adoption has not been without challenges, with limitations in technological infrastructure, teacher training, and connectivity.

The analysis of the results in relation to the findings of the literature review shows that, although significant progress has been made, barriers to the effective implementation of these technologies persist. This indicates the need to strengthen technological capacities, improve the infrastructures of educational institutions, and promote continuous training policies for teachers.

In terms of contribution to literature and practice, this paper offers an up-to-date perspective on how immersive technologies can transform the educational environment. Furthermore, it highlights the importance of an integrated approach that considers both technological and pedagogical aspects to maximize the impact of these tools. This work also demonstrates how streaming services have evolved to overcome some of the limitations identified in the literature review, providing more interactive and accessible solutions.

Finally, the results of this work open multiple opportunities for future research. It would be very important to explore how these technologies can be adapted for educational contexts with limited resources, ensuring equitable implementation. The findings also highlight the need to investigate how the design and functionality of streaming platforms can evolve to meet increasing demands for personalization. These areas of future research can improve the understanding of these technologies and boost their effectiveness in diverse educational contexts.

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