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ORIGINAL

Challenges to Accessibility in Virtual Distance Education: A Bibliometric Study

Desafíos de la accesibilidad en la educación virtual a distancia: un estudio bibliométrico

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ABSTRACT

Introduction: the study provided a comprehensive bibliometric analysis addressing the challenges for virtual distance education, primarily among populations facing significant barriers, such as individuals with disabilities, web accessibility constraints, and those affected by diverse socioeconomic or geopolitical factors.
Method: the analysis encompassed publications from the last ten years. A co-occurrence approach was employed to identify thematic trends, conceptual relationships, and geographic contributions. Data were filtered for relevance and subjected to quantitative indicators (e.g., publication counts by year) to track research evolution.
Results: the findings indicated a marked increase in scholarly attention to enhancing accessibility in virtual education, as evidenced by rising annual publication volumes. The United States, China, and the United Kingdom emerged as the leading contributors to this scientific discourse. Key challenges identified included technological barriers, socio-economic disparities, and the need for inclusive pedagogical strategies targeting marginalized groups.
Conclusions: the analysis underscored the importance of a multidimensional and inclusive approach to advancing digital education. By highlighting persistent obstacles and emerging solutions, the study informed policy, technological innovation, and instructional design aimed at fostering equitable participation in virtual distance education for underrepresented communities.

Keywords: Virtual Education Accessibility; Inclusive Learning Technologies; Digital Divide; Educational Equity.

RESUMEN

Introducción: el estudio proporcionó un análisis bibliométrico comprensivo que aborda los desafíos para la educación virtual a distancia, centrándose en poblaciones que enfrentan obstáculos notables, como personas con discapacidad, problemas de accesibilidad web y aquellas afectadas por diversos factores socioeconómicos o geopolíticos.
Método: se recopilaron publicaciones de los últimos diez años y se empleó un enfoque de coocurrencia para identificar tendencias temáticas, relaciones conceptuales y contribuciones geográficas. Los datos se filtraron para garantizar su relevancia y se examinaron mediante indicadores cuantitativos (por ejemplo, conteo de publicaciones anuales) para trazar la evolución de la investigación.

Resultados: los hallazgos evidenciaron un marcado incremento en la atención académica destinada a mejorar la accesibilidad en la educación virtual, reflejado en el creciente volumen de publicaciones. Estados Unidos, China y el Reino Unido surgieron como los principales contribuyentes al debate científico en este ámbito. Se señalaron desafíos clave, incluyendo las barreras tecnológicas, las desigualdades socioeconómicas y la necesidad de adoptar estrategias pedagógicas inclusivas dirigidas a grupos marginados.
Conclusiones: el análisis destacó la relevancia de adoptar un enfoque multidimensional e inclusivo para impulsar la educación digital. Al visibilizar los obstáculos persistentes y las soluciones emergentes, el estudio ofrece información valiosa para la formulación de políticas, la innovación tecnológica y el diseño instruccional, promoviendo así la participación equitativa de comunidades subrepresentadas en la educación virtual a distancia.

Palabras clave: Accesibilidad en la Educación Virtual; Tecnologías De Aprendizaje Inclusivas; Brecha Digital; Equidad Educativa.

INTRODUCTION

The education landscape has significantly transformed in recent years, promoted by integrating digital technologies and the escalating demand for flexible learning environments.[1] Virtual or distance education is a solution, offering access to educational resources and opportunities across global contexts. However, this shift towards an online paradigm introduces various challenges about accessibility, equity, and the quality of learning experiences.[2] These challenges are multifaceted, encompassing technological, socio-economic, and pedagogical dimensions that require comprehensive exploration.[3]

After the global COVID-19 pandemic, education underwent a transformative shift and unprecedented acceleration toward virtual and distance learning modalities.[4] These changes are not temporary adaptations but a starting point in educational methodologies' evolution, driven by technological advancements and the need for continuity in learning during global disruptions. Virtual platforms and digital tools became integral, facilitating pedagogical strategies for synchronous online classes and asynchronous content delivery.[5] As scholars and educators these new teaching approaches, the post-pandemic times present an opportune moment to critically evaluate the efficacy, inclusivity, and sustainability of virtual and distance education,[6] setting the stage for a comprehensive reimagining of pedagogical practices and infrastructures for the future of distance education.

Through a rigorous bibliometric approach, this study investigates the barriers to accessibility in virtual or distance education. By detecting the dynamics of these challenges, this research aims to find patterns, trends, and gaps in the area. The endeavor is to catalog difficulties and critically analyze how these barriers impact diverse populations, including students with disabilities, learners from low-income backgrounds, and those residing in geographically isolated areas. The significance of this work lies in its potential to inform policymaking, instructional design, and technological innovation, driving the evolution of more inclusive and effective educational models. As the demand for virtual learning continues to rise, understanding these barriers becomes necessary for educators, administrators, and stakeholders interested in fostering equitable access to education.[7]

Focus of the study

This study focuses on determining the multifaceted challenges encountered in accessing virtual and distance education, with a particular emphasis on individuals with disabilities, economic constraints, political situations, geographical limitations, and several other considerations.

Individuals encompassing learning and physical disabilities face significant barriers.[8] Those with visual impairments, including blindness or low vision, often require screen readers, text enlargement, or content in accessible formats.[9] For individuals with hearing impairments, such as deafness or significant hearing loss, learning materials must be available in sign language, with subtitles or content transcripts.[10] People with physical disabilities might need adaptive interfaces, specialized keyboards, or voice recognition software,[11] while those with cognitive disabilities, including learning difficulties, autism spectrum disorders, or attention deficits, benefit from clearly structured educational content, presented in multiple formats without unnecessary distractions.[12] Additionally, individuals with speech disabilities may depend on alternative and augmentative communication technologies.[13]

Economic factors also must be considered, particularly for families with low incomes who might struggle to afford appropriate technological equipment, high-speed internet connections, or specialized educational software.[14]

Political conditions with restrictive regimes or censorship can limit access to educational websites or online platforms.[15] Political instability, conflicts, and unrest disrupt distance education continuity.

Geographical location, whether in rural or remote areas with limited or no access to high-speed internet and adequate technological infrastructure or in congested urban areas where internet connection quality may be poor, significantly affects access to virtual education.[16]

METHOD

This study uses the Scopus database to address the multifaceted nature of accessibility challenges in distance education. The initial phase is bibliometric analysis to map out the most extensively researched obstacles over the past ten years, employing keyword co-occurrence to discern trends in scientific output and identify the countries contributing significantly to this research area. This methodological approach provided a quantitative background to study scholarly attention's evolution toward accessibility in online learning environments.

Bibliometric study

A bibliometric study was initiated utilizing the Scopus database to identify the challenges of web accessibility in distance education.

Search Criteria

The search criteria were designed to capture a broad range of documents addressing both challenges and solutions in the context of distance and virtual education. The search string used was: ("distance education" OR "online learning" OR "e-learning") AND ("challenges" OR "barriers" OR "solutions" OR "strategies")

Initially, the search yielded 217 203 documents, reflecting the growing interest and expansion of literature in this field. To ensure the relevance and timeliness of the analyzed data the search was limited to documents published in the last ten years (2013-2023), focusing on articles in their final state of publication, and considering only those written in English and Spanish. Furthermore, the selection was restricted to documents within specific subject areas to ensure coverage of a diversity of perspectives and applications in the realm of web accessibility in distance and virtual education. The final search string used was:

TITLE-ABS-KEY (("distance education" OR "online learning" OR "e-learning") AND ("challenges" OR "barriers" OR "solutions" OR "strategies")) AND PUBYEAR > 2012 AND PUBYEAR < 2024 AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Spanish")).

Database Treatment and Filtering

The bibliometric analysis focused on the number of articles per year, types of articles, countries with the highest production, and co-occurrence analysis. This process involved several data-cleaning steps to ensure the quality and accuracy of the information analyzed. This treatment included removing duplicates to prevent distortion in the co-occurrence analysis, verifying terminology consistency to ensure variations in spelling or terminology were normalized, and filtering the database to include only those terms present in the keyword fields and abstracts of the documents.

For the co-occurrence analysis, the VOS viewer software was selected as a specialized tool for visualizing and analyzing bibliometric networks. The VOS viewer has allowed mapping and examining the relationships between terms based on their co-occurrence within the database. The co-occurrence threshold was defined at a minimum of 10 appearances of each term per document to ensure only the most relevant terms were included in the analysis.

Co-occurrence analysis through VOSviewer offers a graphical representation of how key terms in the literature are interconnected.[17] This enables the identification of central themes within the field and potential emerging areas of interest.

Various search criteria were chosen to analyze each finding from the first step independently, aiming to examine all the information in the Scopus database. Applying it to each search criteria as detailed in table 1.

Table 1. Overview of Search Criteria and Document Screening Outcomes.

Search criteria	Number of documents obtained after first filters	Number of documents after applying the inclusion and exclusion criteria
("distance education" OR "online learning" OR "e-learning") AND ("disabilities" OR "visual impairment" OR "hearing impairment" OR "physical disability" OR "cognitive disability" OR "speech disability")	n=1813	n=31
("distance education" OR "online learning" OR "e-learning") AND ("economic status" OR "socioeconomic factors" OR "family income" OR "digital divide") AND ("accessibility" OR "technology access" OR "internet access") AND ("challenges" OR "barriers" OR "solutions" OR "strategies")	n=54	n=18

(“distance education” OR “online learning” OR “e-learning”) AND (“political factors” OR “government policy” OR “internet censorship” OR “political instability”)	n=84	n=13
(“distance education” OR “online learning” OR “e-learning”) AND (“prisoners” OR “incarcerated individuals” OR “prison education”)	n=38	n=8

RESULTS

This section presents the findings from the bibliometric analysis conducted on web accessibility challenges in distance and virtual education.

Number of publications by year

The examination of publication trends in web accessibility in distance education over the last decade reveals a pronounced and ascending trajectory. A quadratic polynomial curve fitting was applied to the annual number of publications from 2013 to 2023, demonstrating a substantial increase, particularly from 2020, which aligned with the COVID-19 pandemic and its subsequent effect on the transition towards online learning modalities (figure 1).

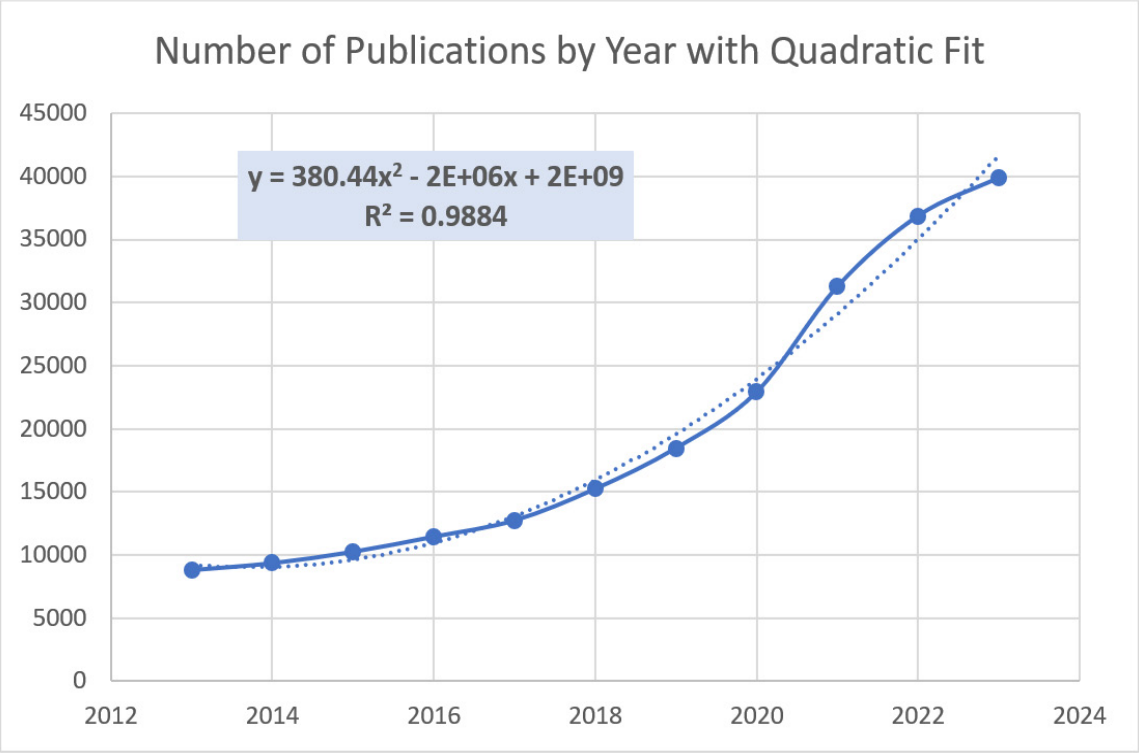

Figure 1. Number of Publications by Year with Quadratic Fit; y= 380,44x2 – 2E+06x + 2E+09, and R2 = 0,988.

The fitted second-degree polynomial curve shows the data’s curvature and indicates an accelerating publication rate over time. The associated coefficient of determination, R2, is 0,988, signaling that the quadratic model explains 98,8 % of the variance in the number of publications per year. This fit quantitatively confirms the substantial growth in research output in this domain and shows that the trend may continue beyond the scope of the pandemic’s immediate impact.

Document Type Analysis

In the bibliometric analysis, documents were categorized by type to gain clearer insight into the nature of academic contributions in web accessibility in distance education. The classification yielded the following breakdown in table 2.

The data in table 2 show the scholarly landscape of web accessibility in virtual and distance education. Articles, representing the majority with 122 418 documents, signify the quantity of original research, serving as a primary source of scientific knowledge. Conference papers with 64 826 documents often provide a snapshot of emergent findings or ongoing research, signaling current trends and potential future directions. The 8 224 reviews underscore their role in critically synthesizing existing literature, thus offering a panoramic view of the field’s status quo. Book chapters, 16 887, enhance academic studies with in-depth discussions on specialized

topics. Figure 2 visually represents these results, providing an immediate understanding of the proportional distribution of document types.

Table 2. Classification and Analysis of Document Types in Web Accessibility Research within Distance and Online Education

Document Type	Number of Documents
Articles	122 418
Conference Papers	64 826
Reviews	8 224
Book Chapters	16 887
Conference Reviews	446
Notes	464
Books	2 574
Editorials	744
Letters	219
Retracted	220
Brief Surveys	108
Errata	9

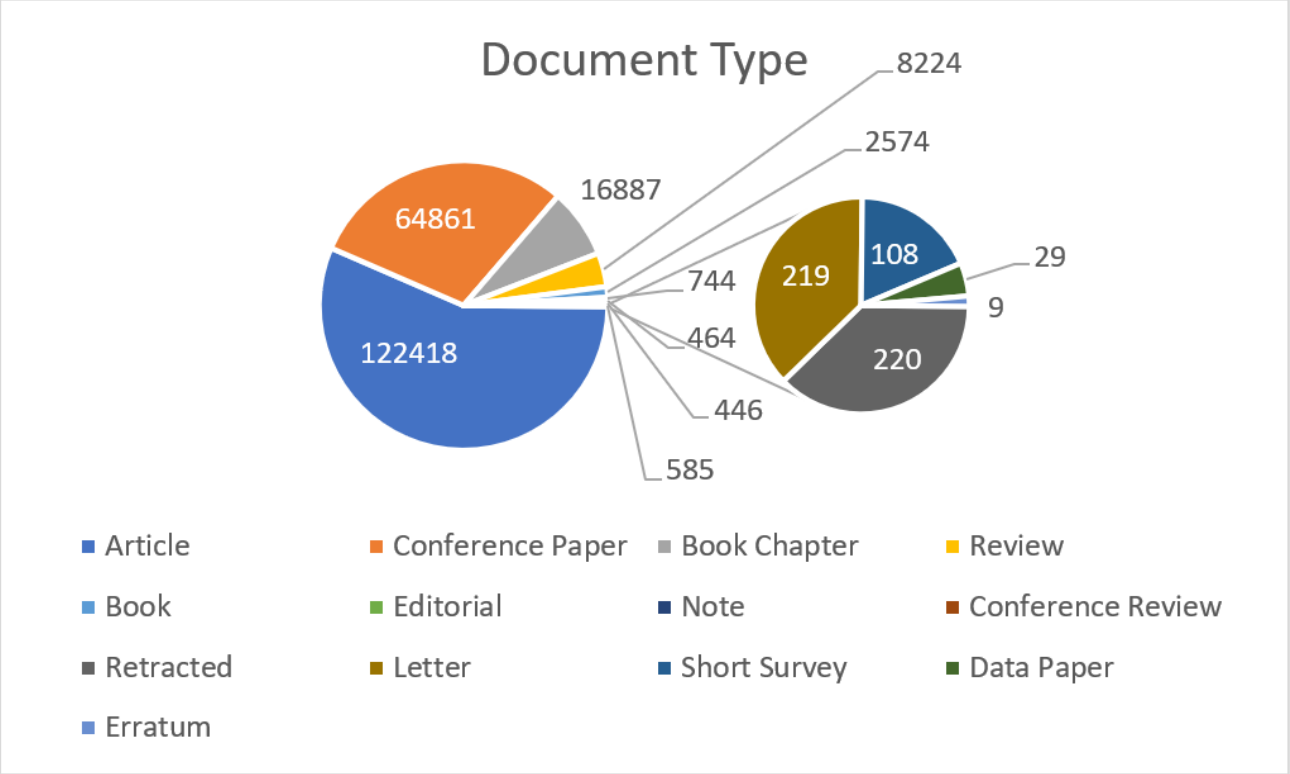

Figure 2. Proportional Distribution of Document Types in the Field of Web Accessibility in Online and Distance Education

Documents by country

The disparity in publication output across different countries, as shown in figure 3, can be attributed to several factors. The United States, China, and the United Kingdom lead the chart with 42 615; 28 972 and 14 733 publications, respectively, indicating a solid academic infrastructure and substantial investment in research and development. These nations have well-established educational systems and significant funding for scientific inquiry. Additionally, these countries have many higher education institutions that actively contribute to the body of literature in the field.

Countries like the Federated States of Micronesia, Burkina Faso, and New Caledonia, with publications as low as 14 and 13, respectively, reflect the impact of limited resources, less developed research infrastructures, and possibly language barriers.

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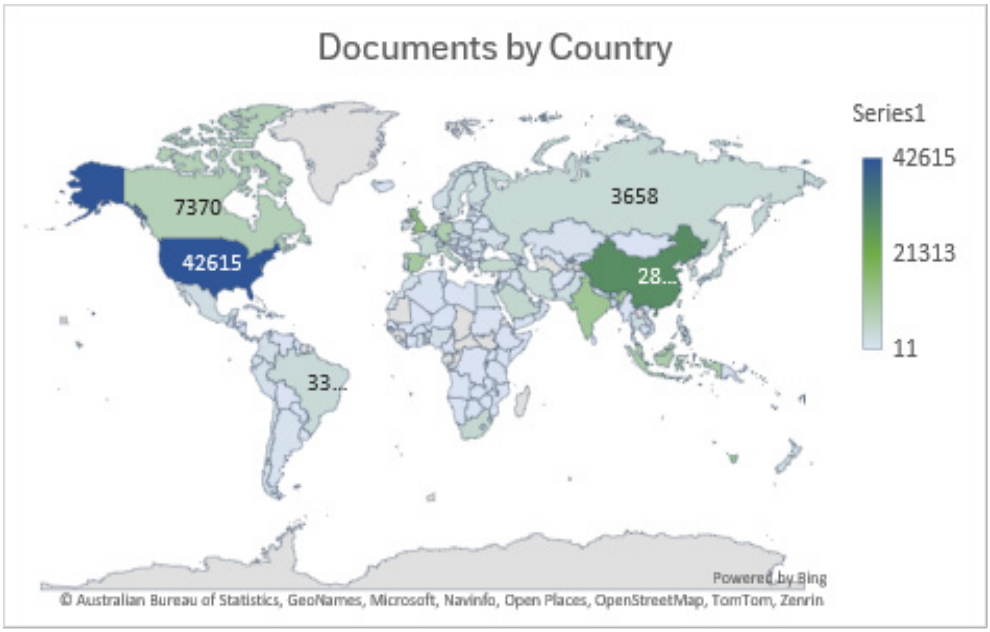

Figure 3. Distribution of Document by Country in the Field of Web Accessibility in Online and Distance Education

This trend indicates the global digital divide regarding access to digital technologies and the ability to contribute to scientific research on web accessibility. It underscores the need for increased collaboration and support to enhance research capacities in less-represented countries to ensure a more equitable distribution of knowledge production.

Co-occurrence Analysis

The co-occurrence analysis in figure 4 shows several key thematic dimensions within the field of web accessibility in distance and virtual education. The visualization presents a network of terms in frequency and relation within the literature. Larger and more interconnected nodes denote the most prevalent terms, and their interconnections imply interrelated research areas.

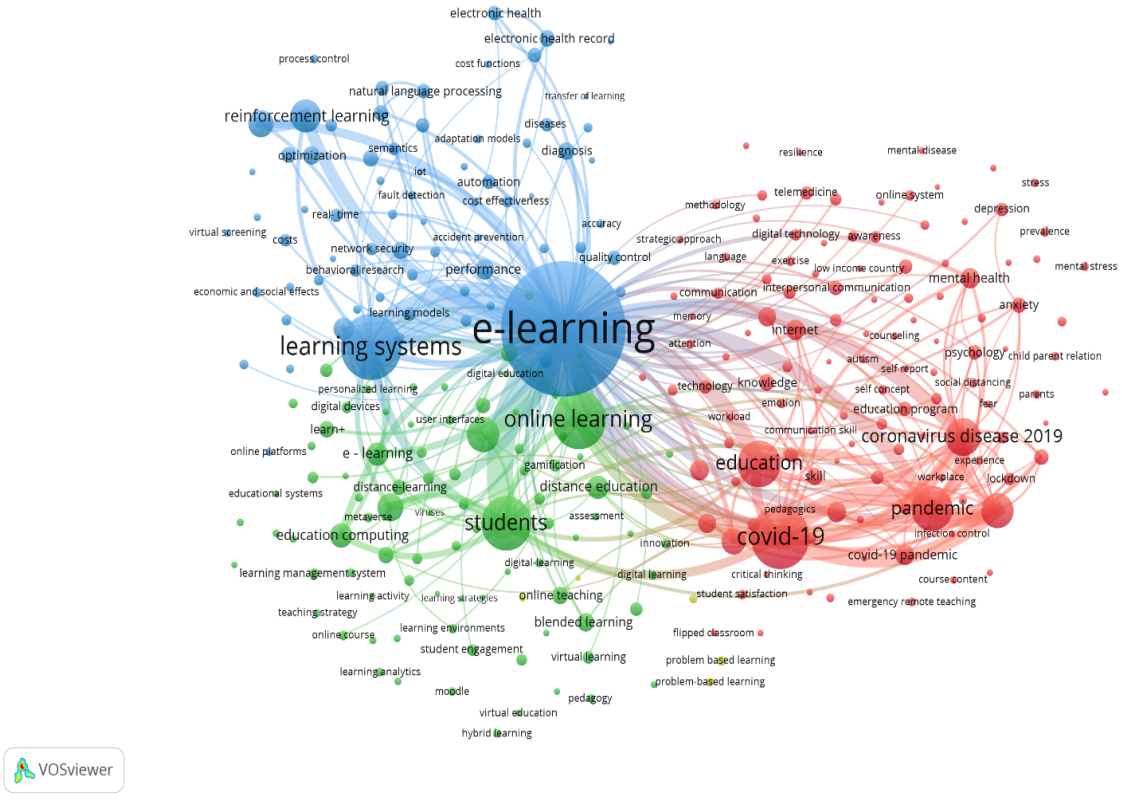

Figure 4. Co-occurrence analysis in the Field of Web Accessibility in Online and Distance Education

The terms "e-learning," "online learning," and "education" form the core of the network, indicating their fundamental position in the literature on distance and virtual education. Their association with terms like "students," "learning systems," and "distance education" shows a focus on the learning process and the delivery of online educational content. The following themes, presented in table 3, are the most significant from this analysis.

Table 3. Key Themes and Descriptions Identified in the Co-occurrence Analysis of Online and Distance Education Literature

Themes	Description
COVID-19 and Its Impact on Education	The pandemic is a disruptive factor, associated with terms such as "pandemic," "coronavirus disease 2019," and "emergency remote teaching." This finding reflects the urgent need for distance education solutions that arose in response to the disruptions caused by the pandemic.
Innovative Teaching Methodologies	Concepts like "blended learning," "flipped classroom," and "problem-based learning" indicate an interest in pedagogical models that integrate technology to enhance the learning experience.
Technology and Educational Tools	Terms like "learning management system," "educational technology," and "digital learning" highlight the importance of digital platforms and technological tools in education delivery.
Accessibility and Student Participation	The co-occurrence of "accessibility" with "students" and "online platforms" emphasizes concerns about inclusion and equitable access to virtual education.

The co-occurrence analysis informed the selection of primary population groups to study challenges and trends in virtual education. The prominence of terms linked to accessibility challenges and student inclusion indicates that certain groups, such as those with disabilities and those affected by economic disparities, encounter barriers in distance and virtual education. Additionally, the keyword network guided the identification of trends in problems and solutions. For instance, terms associated with mental health and student well-being highlight the necessity to address these aspects.

Key identified population groups include individuals with disabilities—visual, auditory, physical, cognitive, and speech—and those affected by family economic status, political situations, geographical location, age and digital literacy levels, and incarceration. These findings support the need for inclusive strategies to support diverse learner demographics.

These focal points have been identified as significant and recurrent in the web accessibility challenges in distance and virtual education. The critical areas are Educational Accessibility for Individuals with Disabilities, Socioeconomic Influences on Distance and Online Education, The Role of Political Factors in Distance and Online Education, and Distance Education in Correctional Facilities.

DISCUSSION

The findings of this study reveal significant growth in scientific output related to virtual and distance education, especially concerning accessibility challenges. The bibliometric analysis confirms that, although scholarly attention to accessibility in online contexts was already solid before COVID-19, the pandemic notably accelerated publications emphasizing inclusivity and equity in virtual teaching environments. The polynomial model (R^2=0,988) applied to publication trends underscores that this upward trajectory is influenced by the educational emergency triggered by the pandemic and structural shifts in educational strategies and policies.

The results show considerable heterogeneity in research outputs. Scientific articles form the most significant portion, followed by conference papers and book chapters, reflecting the breadth and complexity of the field. Research is approached from empirical and theoretical perspectives and through practical lines of inquiry, such as the development of tools and intervention methodologies. Moreover, the presence of conference papers and literature reviews indicates a growing interest in the early exchange of findings and knowledge synthesis, which fosters swift adoption of pedagogical innovations.

When viewed at the country level, production concentrates in regions with advanced research infrastructures—particularly the United States, China, and the United Kingdom—where scientific capacity and funding opportunities are well established. In contrast, regions with limited resources or weaker digital infrastructures show very low publication outputs, reaffirming a "digital divide" that extends into scientific research endeavors. Because digital accessibility is closely tied to technological capacity, these disparities highlight the urgency of promoting international collaboration and targeted funding to narrow these gaps.

Co-occurrence analysis brings to the forefront key terms such as "e-learning," "distance education," and "online learning," which links with "accessibility," "inclusion," and "students." This connection underscores a common concern about whether virtual learning environments adequately prevent or reduce educational inequities. Moreover, references to "COVID-19" and "pandemic" confirm the catalytic role of the public health

crisis in reconfiguring educational models. Collectively, the findings illustrate the need to revise regulatory frameworks, pedagogical strategies, and technology investments to ensure that online education is genuinely accessible to diverse populations, including those with disabilities, limited economic means, remote locations, restrictive political contexts, and even individuals serving prison sentences.

The trends identified point toward consolidation of research on the adaptation of technologies and universal design learning for various disabilities—visual, auditory, motor, cognitive, and speech—and attention to socioeconomic and political factors that influence the quality and continuity of online learning. Although much of the literature recognizes the need for inclusive frameworks, persistent gaps remain. These include (a) teacher training geared toward digital accessibility, (b) the availability of digital platforms that accommodate varying levels of digital literacy, and (c) the scalability and sustainability of initiatives aimed at economic or geographic barriers.

Another relevant observation emphasizes innovative methodologies—blended learning, flipped classrooms, and project-based approaches—to optimize the online learning experience. However, the effectiveness of these methods is contingent upon an educational ecosystem where students have suitable devices, reliable connectivity, and learning materials developed under-recognized accessibility standards. Without a holistic strategy for inclusion, adopting pedagogical innovations could reinforce new forms of exclusion.

CONCLUSIONS

The results aligned with earlier studies indicating how the rapid transition to online learning during COVID-19 exposed multiple infrastructure and training deficiencies for teachers and students. This research adds to that body of knowledge by demonstrating a notable increase in publications between 2020 and 2023, confirming that populations facing the most significant barriers remain those with limited financial resources, disabilities, or restricted access to stable internet. In this context, the study enriches global conversation by consolidating and systematizing recent developments, offering an updated landscape of the theoretical and practical approaches that have emerged to address such challenges.

The study opens avenues for further research. Qualitative or mixed-method approaches would offer more profound insights into how accessibility barriers manifest in different sociocultural settings. Likewise, investigations focusing on subpopulation such as students with cognitive disabilities or those in correctional facilities—could shed light on particular pedagogical and technological needs. It is also worth exploring the effectiveness of teacher training interventions aimed at enhancing digital competencies and the ability to design inclusive learning experiences.

The findings show sustained growth in scientific output related to accessibility in virtual and distance education, primarily influenced by COVID-19. The concentration of research in regions with advanced scientific infrastructure and persistent challenges among vulnerable groups reveals an uneven landscape that requires policy action, international cooperation, and inclusive technological development strategies. These bibliometric insights and thematic explorations emphasize the urgency of coordinating efforts across multiple sectors to achieve virtual education systems that are genuinely accessible, equitable, and of high quality.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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