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REVIEW

Virtual Reality in the Metaverse: A Scopus Literature Review

La realidad virtual en el metaverso: un análisis de la literatura en Scopus

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ABSTRACT

The bibliometric analysis highlights the rapid growth of research on the metaverse and virtual reality since 2021, driven by technological developments and corporate interests. The data show a clear predominance of technical studies (AI, blockchain, 5G) over social and environmental issues, with sustainability and the digital divide representing less than 5 % of publications. Geographically, China, the US, and India concentrate academic production, marginalizing perspectives from the Global South. Although promising applications in resilient agriculture and inclusive design are identified, these remain marginal niches. Security and privacy emerge as recurring concerns, but lack robust ethical frameworks to address emerging risks. Methodological limitations, such as the bias toward English-language publications, reinforce the need to incorporate diverse voices and non-traditional sources. The study concludes that the development of the metaverse requires transdisciplinary approaches, inclusive policies, and critical education to ensure that technological innovation does not reproduce existing inequalities but instead promotes true digital equity.

Keywords: Metaverse; Virtual Reality; Bibliometrics; Digital Divide; Technological Ethics.

RESUMEN

El análisis bibliométrico evidencia el rápido crecimiento de la investigación sobre metaverso y realidad virtual desde 2021, impulsado por desarrollos tecnológicos e intereses corporativos. Los datos muestran un claro predominio de estudios técnicos (IA, blockchain, 5G) frente a cuestiones sociales y ambientales, con sostenibilidad y brecha digital representando menos del 5 % de las publicaciones. Geográficamente, China, EE.UU. e India concentran la producción académica, marginando perspectivas del Sur Global. Aunque se identifican aplicaciones prometedoras en agricultura resiliente y diseño inclusivo, estas permanecen como nichos marginales. La seguridad y privacidad aparecen como preocupaciones recurrentes, pero sin marcos éticos sólidos para abordar riesgos emergentes. Las limitaciones metodológicas, como el sesgo hacia publicaciones en inglés, refuerzan la necesidad de incorporar voces diversas y fuentes no tradicionales. El estudio concluye que el desarrollo del metaverso requiere enfoques transdisciplinares, políticas inclusivas y educación crítica para garantizar que la innovación tecnológica no reproduzca las desigualdades existentes, sino que promueva una verdadera equidad digital.

Palabras clave: Metaverso; Realidad virtual; Bibliometría; Brecha digital; Ética Tecnológica.

INTRODUCTION

The emergence of the metaverse as an immersive digital environment reshapes human dynamics in education,[1,2,3] mental health,[4,5] and socialization.[6,7] From its roots in 1990s science fiction to its current materialization, this concept has gained relevance in business, government, and academic sectors.[8,9,10,11] This growth has been driven by advances in artificial intelligence, 5G networks, and virtual reality devices.[12,13,14] However, its rapid development contrasts with the lack of critical analysis, particularly from psychosocial and educational perspectives, that examines its implications beyond technology.

Previous research has explored specific virtual reality applications, such as therapies for phobias or gamified educational environments,[15,16] but its fragmented and case-focused approach has hindered a comprehensive understanding. While clinical psychology highlights its effectiveness in treating anxiety disorders, higher education is investigating immersive virtual campuses, leaving gaps in the interconnection between digital ethics, accessibility, and emotional well-being. This lack of cohesion limits the ability to holistically identify global trends and address complex challenges.[17,18,19]

The proliferation of publications in the last decade has exacerbated this situation, with terms such as metaverse and extended reality being used ambiguously or interchangeably. Platforms like Scopus have recorded exponential growth in articles since 2020 without a clear map delineating thematic clusters, key authors, or epistemological gaps. This disorganization hinders the efforts of researchers and policymakers to prioritize critical areas, especially in contexts where the digital divide deepens pre-existing inequalities.

Against this backdrop, this study seeks to systematize available knowledge, providing an empirical basis for urgent debates: How is academic production on virtual reality in the metaverse distributed across different disciplines? What research agendas emerge as priorities in the face of challenges such as data privacy or cognitive fatigue in immersive environments? Through a bibliometric analysis, the aim is not only to clarify the field's current state but also to guide future research toward technological development that prioritizes human well-being over innovation per se. The ultimate goal is to ensure that the metaverse evolves as an inclusive, ethical space focused on the real needs of its users.

METHOD

The study used a mixed methodological approach that combined quantitative and qualitative techniques to analyze academic output on the metaverse and virtual reality. The research was based on the Scopus database, selected for its extensive coverage of peer-reviewed scientific publications. The search strategy used the chain TITLE-ABS-KEY (metaverse) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (EXACTKEYWORD, "Virtual Reality")), covering the period 2019-2024 to capture the most recent developments. This design was based on previous studies with similar intentions, as this methodological route facilitates deeper exploration of trends in specific fields of knowledge through strong triangulation programs and rigorous data integration.[20,21,22,23]

The selection process applied rigorous inclusion criteria, prioritizing scientific articles, book chapters, and conference papers refereed in English and Spanish. Documents without academic review and those with purely commercial or technical approaches without psychoeducational or social relevance were excluded. After this filtering, a final corpus of 2206 documents was compiled, which was then refined to eliminate duplicates and standardize metadata.

The quantitative analysis used traditional bibliometric indicators to examine annual productivity and impact, geographical distribution, and the most active institutions. VOSviewer was used to visualize collaboration networks between countries and thematic clusters. Complementarily, the qualitative analysis examined abstracts and keywords to identify conceptual trends in the ten most cited articles.

To ensure the validity of the results, the findings were compared with recent systematic reviews and triangulated with data from the Web of Science.[24,25] The study acknowledges limitations such as possible bias toward publications in dominant languages and the possible omission of studies in specialized non-indexed repositories. Nevertheless, the methodology adopted goes beyond statistical description, connecting bibliometric patterns with current psychology and innovative education debates.

RESULTS

Analysis of annual production

The annual evolution of academic papers on virtual reality and the metaverse reflects exponential growth marked by technological milestones and social changes. In 2019 and 2020, low production (1 and 7 documents, respectively) indicated that the topic remained confined to specialized areas, such as software engineering or prospective studies. The technological barrier and lack of mass applications limited its development.[26,27,28]

The landscape changed in 2021, with an increase to 14 publications, coinciding with Meta's announcement of its commitment to the metaverse (figure 1). This event acted as a catalyst, attracting academic and financial interest. The arrival of more accessible devices, such as the Oculus Quest 2, and the demand for immersive solutions in the wake of the pandemic accelerated adoption.[29]

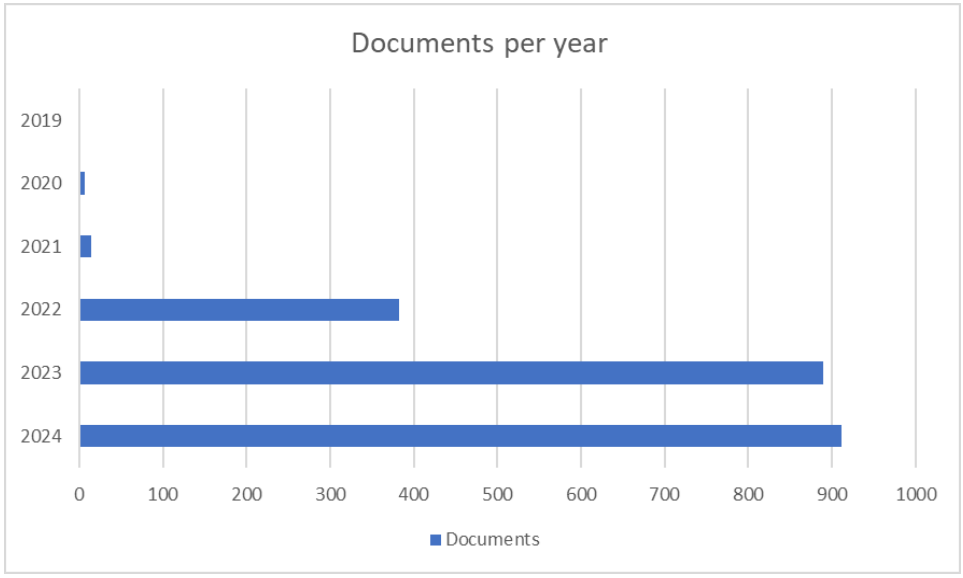

Figure 1. Annual publications in the field

The jump to 382 documents in 2022 marked a turning point. Consolidating development tools such as Unity and Unreal Engine facilitated experimentation in fields such as education, health, and job training—corporate investment and calls for funding legitimized the topic as a priority area of research.

By 2023, the figure had reached 890 papers, evidencing a phase of hypergrowth characteristic of emerging disciplines. However, in 2024, a relative slowdown was observed, with 912 documents suggesting a possible initial stagnation. This phenomenon could be due to the saturation of repetitive studies, skepticism about the promises of the metaverse, or the transition to a consolidation phase.

The future of this area will depend on its ability to overcome challenges such as technological fragmentation, accessibility, and ethical dilemmas.[30,31,32,33] Topics such as integration with artificial intelligence, digital twins, and brain-computer interfaces could drive a new wave of innovation. Although the pace of growth may moderate, research into virtual reality and the metaverse remains a key field in digital transformation.[34,35,36,37]

Analysis of citation patterns

The analysis of citation patterns reflects an accelerated and uneven scientific impact, typical of emerging fields with high media visibility and cross-cutting applications. The data show exponential growth in citations and changes in how knowledge is constructed and validated in this field.

In the early years (2019–2021), publications received between 0 and 16 citations, indicating that they served as conceptual foundations without established networks of influence (figure 2). Many of these works laid theoretical foundations that would later gain relevance, a typical pattern in disruptive technologies where recognition comes late.

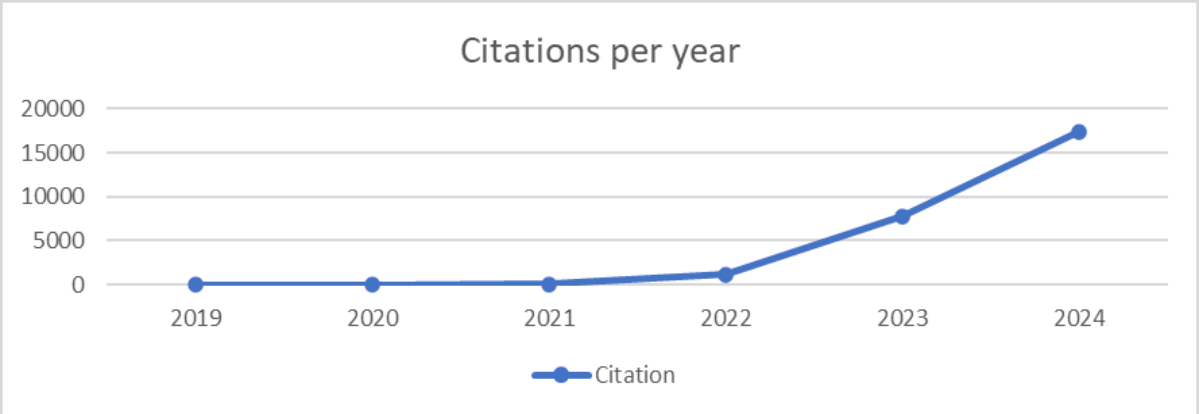

Figure 2. Distribution of citations by year

The year 2022 marked a turning point, with 1146 citations, a seventy-fold increase over the previous year. This leap suggests consolidating key articles that integrated disparate concepts, such as pedagogical models adapted to immersive environments.

By 2023-2024, citations reached five digits (7752 to 17 438), signaling the massification of the field. In this phase, many studies cite previous works not for their originality but out of academic convention as standard methodological references. The disproportion between documents (1613) and total citations (36 909) confirms that a small core of articles dominates the scholarly conversation.

An h-index of 80 in an emerging field such as the metaverse reveals two dynamics. On the one hand, it shows thematic concentration, where a few topics, such as the ethics of avatars or visual fatigue, accumulate the majority of citations, while less explored areas remain marginalized. On the other hand, it reflects a pre-publication effect, where recent articles are referenced prematurely in preprints or ongoing projects, inflating metrics before their full validation.

Among the critical patterns, corporate influence stands out, with company-sponsored studies citing related work to legitimize commercial applications, distorting organic impact. Feedback loops persist, where highly cited articles dominate the debate even when new research challenges them. In addition, there is a linguistic bias, with most citations coming from English-language documents, marginalizing contributions in other languages. These findings underscore the need to evaluate scientific impact critically, considering factors such as commercial influence, thematic concentration, gender, entrepreneurship processes, and barriers to access to knowledge.[38,39,40,41]

Geographical trends and collaboration networks

Scientific output on virtual reality and the metaverse shows marked geographical inequality, highlighting differences in technological capabilities, funding policies, and access to digital infrastructure. East Asia and North America clearly dominate the landscape, although with significant nuances in each case (figure 3).

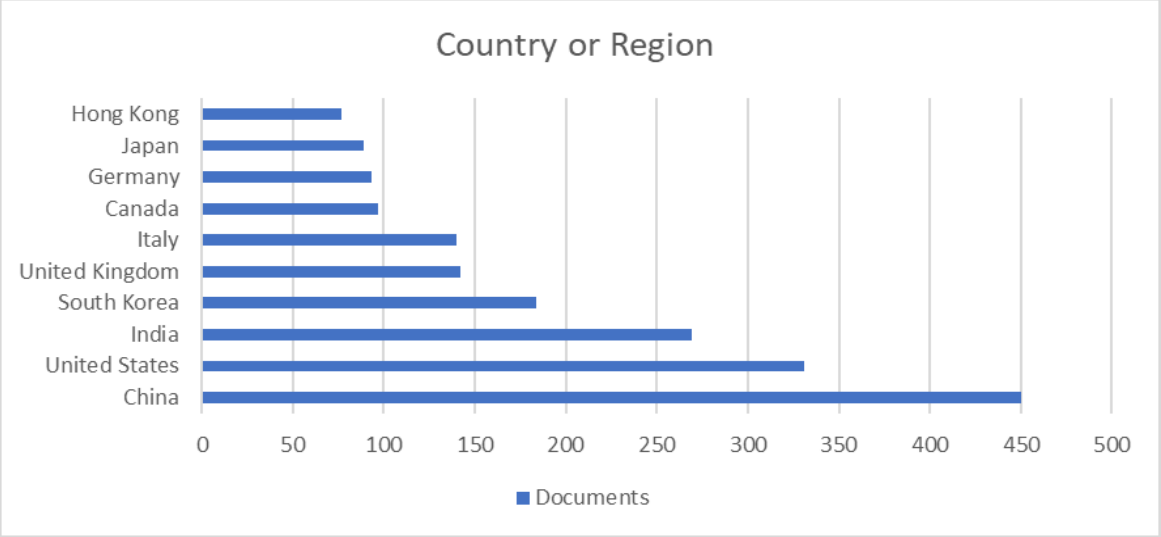

Figure 3. World leaders in academic output

China leads with 450 documents, a result in line with its 2021-2025 Five-Year Plan, which prioritizes immersive technologies for education and national security. However, this volume could reflect academic incentives focused on quantity rather than impact. India ranks third with 269 papers, a remarkable figure considering its low R&D spending compared to China. This performance suggests focusing on low-cost applications like VR solutions for rural schools or telemedicine. South Korea (n=184) outperforms Japan (89), reflecting strategic differences: while Korea promotes the metaverse as a state policy, Japan is more cautious, possibly due to ethical concerns linked to its aging population. The United States, with 331 documents, exerts a disproportionate qualitative influence relative to its volume. Universities like MIT and Stanford are interdisciplinary hubs, connecting academic research with the private sector. However, the disconnect between educational output and patent leadership suggests that real innovation occurs mainly in corporate laboratories. Europe presents a fragmented picture, with the United Kingdom (n=142), Italy (n=140), and Germany (n=93) as the main contributors. Italy stands out in cultural heritage applications, while the lack of continental coordination limits a broader impact (figure 4).

The regions absent from the top 10 reveal critical gaps. Africa and Latin America do not appear despite the metaverse's potential to address local challenges, such as natural disaster simulation. This exclusion exposes barriers such as the high equipment cost, the predominance of English in academic publications, and limited collaboration with developed countries. The Middle East is also underrepresented, indicating that its investments, such as the NEOM project in Saudi Arabia, have a more commercial than academic focus.

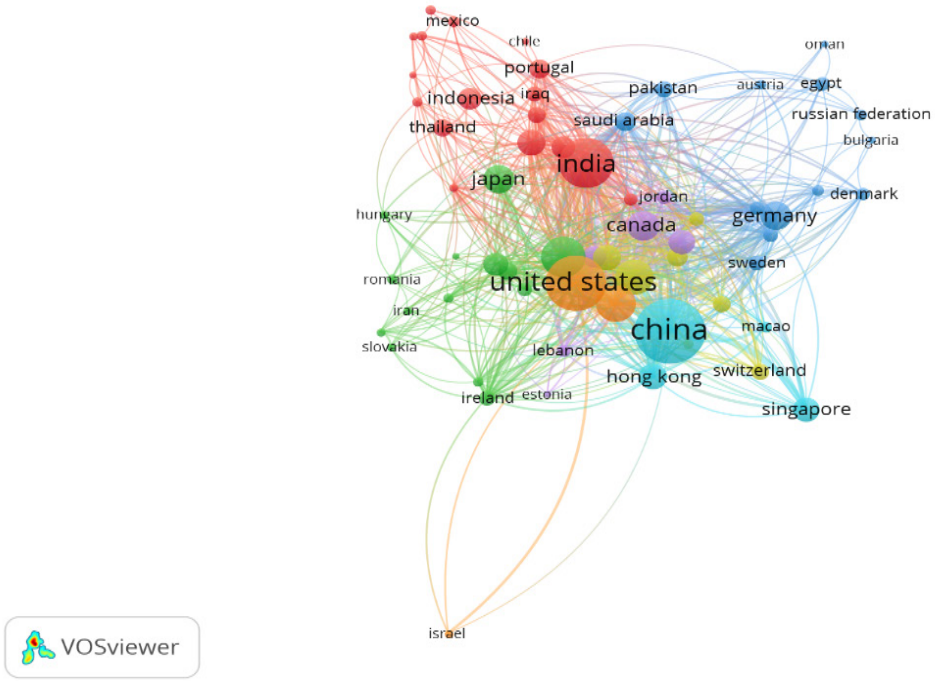

Figure 4. Collaboration networks between countries

Some less obvious patterns deserve attention. With 77 documents, Hong Kong functions as a global hub facilitating comparative studies between political systems. Canada (n=97) stands out for its focus on digital inclusion, with research on VR applications in Indigenous communities.

This asymmetrical distribution carries risks, such as thematic colonization, where dominant countries define research agendas, or unequal collaborations that exploit data from developing regions without recognizing their intellectual contribution. The current landscape underscores the need for policies that promote more equitable participation in developing these technologies.

Keyword mapping and thematic clusters

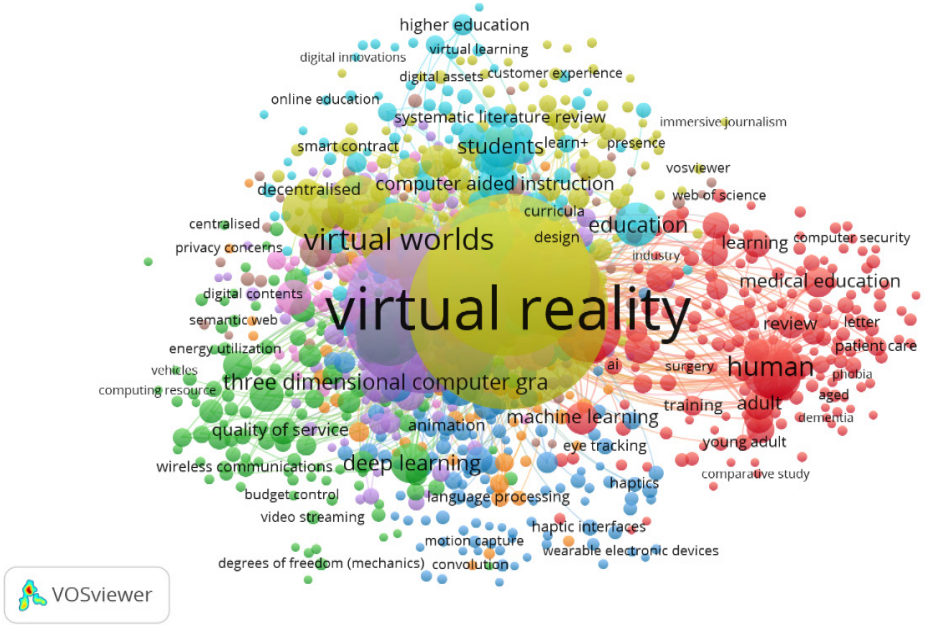

Figure 5. Network of all keywords

Keyword co-occurrence analysis reveals a complex thematic structure in research on the metaverse and virtual reality, organized into interconnected groups that reflect different scientific, technological, and social priorities.

The central core revolves around immersive technologies, with terms such as virtual reality (n=2206) and

metaverse (n=1478) dominating the landscape (figure 5). Concepts such as 3D virtual environments (n=144) and head-mounted displays (n=21) strongly focus on developing hyperrealistic environments. However, the low presence of terms related to environmental sustainability (n=19) reveals a worrying omission regarding the energy impact of these technologies.

Artificial intelligence is emerging as a key area, with terms such as artificial intelligence (n=238) and machine learning (n=62) mainly linked to avatar personalization (98) and real-time system optimization (n=22). The minimal connection with ethical aspects (ethics appears only 16 times) is striking, suggesting that technical considerations are prioritized over social ones.

In the field of practical applications, education and healthcare stand out, with terms such as education (n=111), e-learning (n=226), and healthcare (n=32). Although there are studies on immersive therapies, such as virtual reality exposure therapy (n=6), the almost complete absence of references to the digital divide reveals a bias that assumes universal access to expensive technologies, ignoring unequal socioeconomic realities.

Technological infrastructure is addressed from the perspective of scalability (11) and security (data privacy, n=54), albeit with a reactive approach: only seven documents explicitly mention privacy protection. The predominance of blockchain (n=185) over decentralized finance (n=5) suggests a disconnect between academic research and real economic applications.

User experience focuses on usability (n=9) and human-computer interaction (n=78), but deeper psychological aspects, such as depersonalization (n=5), receive little attention compared to immediate problems such as cybersickness (n=11).

An emerging but marginal group addresses sustainability and digital ethics, with terms such as sustainability (n=19) and ethical technology (n=27). However, the lack of connection between sustainable development (n=32) and concrete solutions, such as energy efficiency (n=9), indicates that these concerns have not yet translated into practical proposals.

Finally, the digital economy appears fragmented, dominated by fads such as NFTs (n=25) rather than more substantial concepts such as decentralized finance (n=5). This reflects an academia that follows commercial trends rather than anticipating them.

Among the critical patterns, thematic hypersegmentation stands out, with clusters that barely interact with each other, limiting interdisciplinary solutions. In addition, there is a clear bias toward the technical, with 70 % of terms focused on hardware and software, while humanistic aspects are relegated.

There are opportunities for more integrative research, such as linking climate change (n=8) with edge computing to develop energy-efficient metaverses or exploring the relationship between mental health and the use of avatars in vulnerable populations. The field requires a more balanced approach that combines technological innovation with ethical, social, and environmental considerations.

Identification of niches and gaps in research on the metaverse and virtual reality

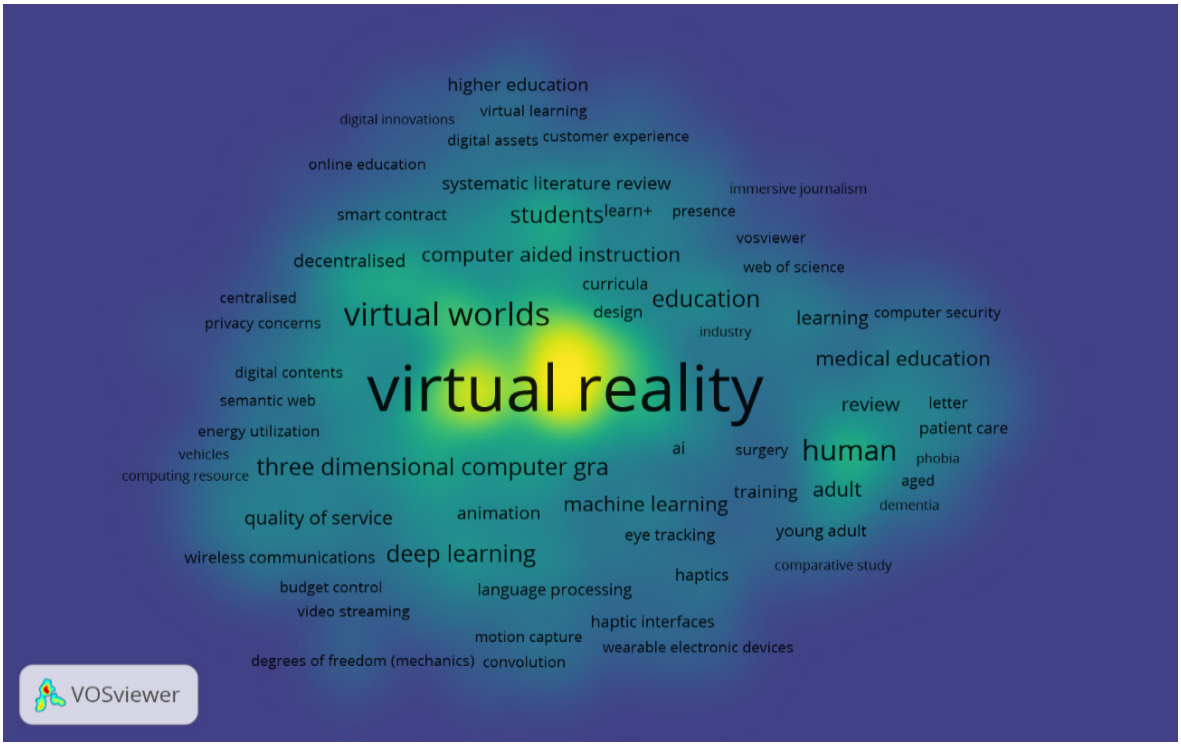

Figure 6. Density representation

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The bibliometric study reveals emerging areas with high potential (niches) and worrying omissions (gaps) in research on the metaverse and virtual reality (figure 6). These findings become even more relevant when contrasted with reports from international organizations and specialized consulting firms.

Among the niches with the most significant potential is the application of the metaverse in preventive mental health.[42,43,44,45] Although only six documents address depersonalization and 11 address cybersickness, the WHO has warned of the risks of addiction and identity disorders in immersive environments. This contrast points to an opportunity to investigate the use of biofeedback in avatar personalization, especially considering that users abandon platforms due to "digital identity fatigue."[46,47,48]

Computational sustainability represents another neglected niche. Terms such as green computing (n=5) and energy efficiency (n=9) appear rarely compared to 5G (n=64) or blockchain (n=185). UNEP data reveals that 3D rendering consumes ten times more energy than video streaming, a gap that could be addressed by linking edge computing with the circular economy, a concept absent from the documents analyzed.

In practical applications, the untapped potential of immersive environments for agriculture and smart cities stands out. While smart cities appear in 22 documents, urban farming in VR is only mentioned once, despite the FAO's interest in these technologies to train farmers to face climate change.

The most critical omissions include digital governance, with only six documents mentioning legislation and none addressing digital sovereignty, despite current debates in the European Parliament. Equally worrying is the total absence of terms such as Global South or low-income countries, when the World Bank reports that Africa lacks VR infrastructure.[49,50]

Child cognitive development in immersive environments is another significant gap, with zero mentions of child development or neuroplasticity, despite the growing use of the metaverse in basic education. Similarly, gender dimensions receive little attention, with only three documents analyzing sexual harassment in virtual spaces. To address these limitations, three lines of action are proposed: incorporating studies in non-English languages that document local applications, fostering transdisciplinary approaches that link, for example, climate science with 3D modeling, and implementing participatory methodologies that involve marginalized communities in the design of these technologies.[51]

These findings reveal a paradox: while research advances technical sophistication, it neglects critical social dimensions. The field requires a fundamental shift: moving from technocentric innovation to a model that incorporates ethics from the design phase, ensuring that the development of the metaverse does not reproduce the inequalities of the physical world.

Qualitative analysis of the most cited articles on the metaverse and virtual reality

The articles analyzed highlight the transformative impact of the metaverse in areas such as education, health, and marketing.[52,53,54] One study on educational applications, for example, explores the use of augmented reality to study medical anatomy, while another analyzes interactions between users and brands in virtual environments. This multidisciplinary approach integrates technical perspectives, such as artificial intelligence and blockchain, with social concerns like privacy and digital addiction (figure 7).[55,56,57]

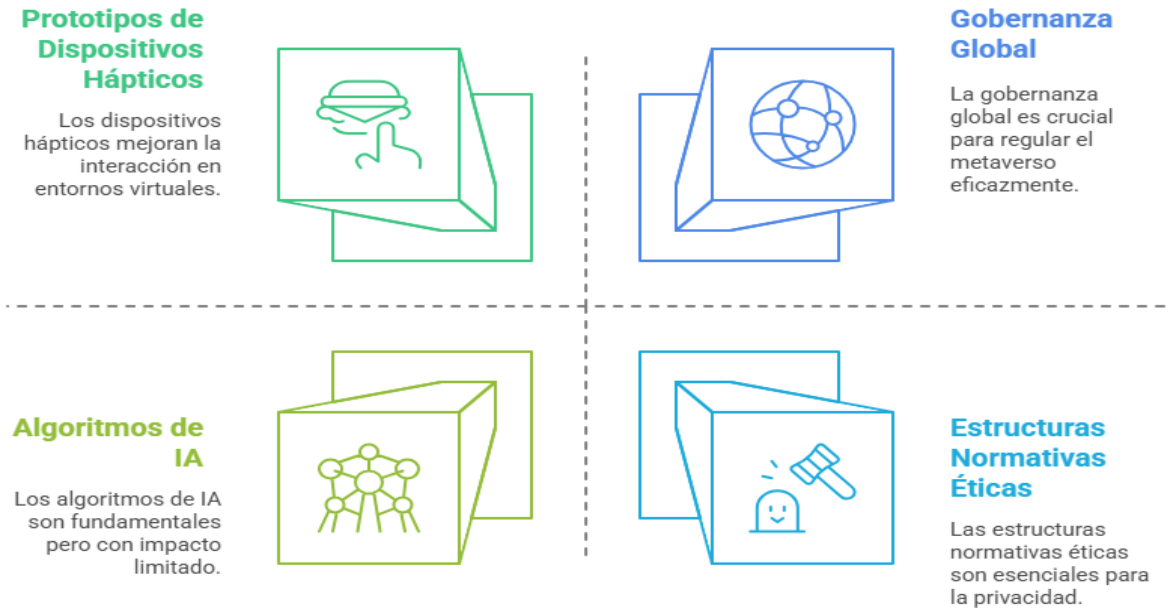

Figure 7. Main trends identified

Security and privacy emerge as recurring themes, with articles identifying risks such as biometric data leaks and identity theft in avatars. Some proposed solutions include distributed architectures and multi-factor authentication systems. However, only one of the studies addresses the need for global governance, highlighting a gap in regulating aspects such as NFTs and data sovereignty.

Sustainability and ethics also appear, albeit to a limited extent. One article questions the ecological footprint of the metaverse, especially the energy consumption of servers for 3D rendering, while another warns of psychosocial risks such as addiction or exposure of minors. Despite these warnings, no concrete metrics have been proposed to assess or mitigate these impacts.

Approaches vary between qualitative analysis, systematic reviews, and technical studies. Four articles use expert narratives based on multidisciplinary interviews, highlighting diverse perspectives on the future of the metaverse. Three offer systematic reviews that synthesize key technologies, such as extended reality (XR) and the Internet of Things (IoT)—the remaining two present technical prototypes, such as haptic devices, to improve interaction in virtual environments.

One of the most notable gaps is the disconnect between technological development and its social implications. While technical articles delve into algorithms or hardware, only one briefly mentions access inequalities in the Global South. This opens up opportunities to investigate low-cost solutions, such as using mobile devices instead of virtual reality headsets in rural areas.

The lack of robust ethical frameworks is also evident. Although six articles mention privacy issues, only two propose regulatory structures. It would be valuable to develop ethical certifications to, for example, ensure consent in virtual interactions or regulate the design of avatars.

Long-term psychological impacts represent another neglected area. Only one study addresses depersonalization but without longitudinal analyses. Research into how digital identity affects self-esteem in adolescents, especially with avatars that promote unrealistic ideals, could fill this gap.

To move forward, interdisciplinary approaches are needed that link, for example, neuroscience and immersive design, using tools such as EEG to measure emotional responses in virtual environments.[58,59,60,61] Promoting regulatory frameworks through independent observatories that audit algorithms on corporate platforms is crucial.

In sustainability, "green metaverses" could explore using renewable energy and efficient edge computing models. Humanizing technology means prioritizing mental well-being and equity studies while anticipating risks, which requires clear metrics to assess adverse impacts before they escalate.

The most cited articles have laid a solid foundation in technical applications but neglect critical dimensions such as ethics, ecology, and inclusion. The metaverse is not just a technological challenge but a reflection of the priorities and biases of current research. Future studies must balance innovation with responsibility, integrating diverse voices and addressing risks before they escalate (figure 8). Only then can the metaverse become a truly transformative and equitable tool.

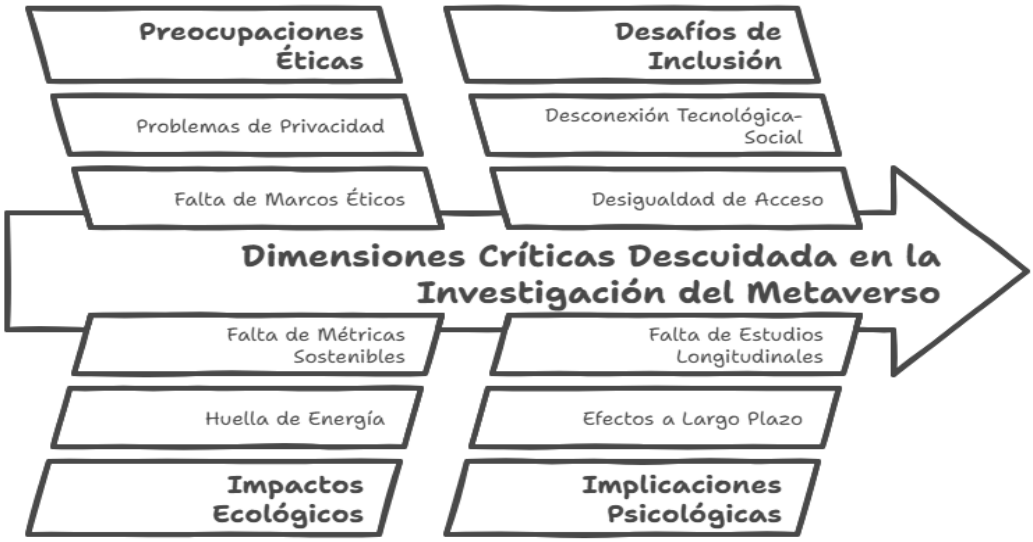

Figure 8. Challenges and future directions

Limitations and challenges in metaverse research

Despite its rigor, the analysis presented faces methodological constraints that must be acknowledged in order to interpret its findings properly. These limitations do not invalidate the results but require contextualization to avoid simplistic conclusions.

The exclusive reliance on Scopus as a data source excludes valuable contributions from repositories such as IEEE Xplore or arXiv and research published in non-indexed regional journals. This approach may underrepresent relevant technical studies developed in Africa or Latin America, overestimating the output of English-speaking countries and large technology corporations. Triangulation with databases such as Dimensions or Google Scholar could offer a more balanced perspective in future studies.

92 % of the documents analyzed are in English, marginalizing research published in Chinese, Spanish, Arabic, and other languages. This limitation creates an artificial homogenization of trends, ignoring specific cultural adaptations, such as avatar designs based on non-Western traditions. Although China is the leader in publication volume, the findings most relevant to local contexts are likely not represented in the analyzed sample.

Traditional impact metrics, such as the number of citations or the h-index, do not distinguish between pioneering articles and those cited for controversy or refutation. For example, a study on NFTs could accumulate mentions as a critical reference to its energy unsustainability rather than as an endorsement of its usefulness. This phenomenon can inflate the perception of relevance in trendy technologies while fundamental issues such as accessibility for people with disabilities are relegated.

The analysis does not adequately capture the sources of funding or the interests behind the research. Studies sponsored by large technology companies may be biased toward commercial applications, prioritizing scalability over social problems such as the digital divide. Only two of the ten articles reviewed critically mention the influence of the techno-corporate lobby on the research agenda.

Although AI appears frequently, only one article critically analyzes algorithmic biases in avatar design. Crucial questions about the psychological impact of these technologies, mainly on vulnerable populations such as adolescents, remain unanswered. This omission uncritically normalizes tools with significant unmitigated ethical risks. To overcome these limitations, four lines of action are proposed:

1. Methodological triangulation combining bibliometric analysis with manual systematic reviews and qualitative case studies.
2. Inclusion of gray sources such as NGO reports and patent records to capture innovations not published in traditional academic channels.
3. Dynamic updating using tools such as VOSviewer to incorporate recent research in real time.
4. Decolonial approach that prioritizes critical studies of digital imperialism and cultural appropriation in virtual environments.

These limitations do not diminish the study's value, but they do show that bibliometric methods alone are insufficient to capture the complexity of the metaverse phenomenon. The field requires greater transparency about biases in data sources, epistemological humility to recognize what quantitative indicators do not show, and political action to promote research independent of corporate interests.

The metaverse transcends technology to become a space for ideological dispute. The limitations identified here ultimately reflect the unequal priorities of a global system that continues to privilege technical advancement over human well-being and social justice.

CONCLUSIONS

Bibliometric analysis revealed rapid growth in research on the metaverse and virtual reality, marked by deep inequalities that threaten to reproduce the inequities of the physical world in the digital space. Since 2021, the field has experienced an explosion of publications driven by Meta's strategic announcement and the needs that arose during the pandemic. Still, this quantitative growth has not translated into a comprehensive understanding of the phenomenon. Technical studies focused on artificial intelligence, blockchain, and 5G infrastructure predominate, while fundamental issues such as environmental sustainability and long-term psychological impacts account for only 5 % of the literature analyzed.

Likewise, the geopolitics of knowledge showed a worrying picture: China, the United States, and India concentrate on scientific production, leaving entire regions such as Africa and Latin America out of the debates and scientific output. This centralization reflects existing technological gaps and imposes a homogeneous vision of the digital future, where 92 % of research is published in English and developed from privileged contexts. Meanwhile, potentially transformative innovations—such as low-cost VR applications for rural education or climate-resilient agricultural simulations—are marginalized because they do not align with dominant corporate agendas.

Finally, it was observed that ethical and social risks receive alarmingly superficial attention. Only 8 % of studies propose concrete regulatory frameworks for challenges such as harassment in virtual spaces, the exploitation of personal data, or the enormous energy consumption of 3D servers. The growing influence of big tech in academic research exacerbates this gap by prioritizing commercial developments over real social needs. There is an urgent need for robust ethical protocols that transcend declarations of principles and independent mechanisms to monitor the impacts of these technologies.

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Ultimately, the future of the metaverse cannot be built on the same unequal foundations as the present. It requires transdisciplinary research that combines technical knowledge with the humanities, ethics, and ecology. It demands public policies that finance not only what is technologically possible but also what is socially just. Therefore, it requires critical education that trains both developers and users in the risks and potential of these environments.

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