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VIRTUAL MUSEUM RESEARCH: A BIBLIOMETRIC MAPPING

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Abstract:

The rapid advancement of immersive technologies has significantly transformed how cultural heritage is preserved, experienced, and disseminated through virtual museum platforms. Despite the growing scholarly interest, there remains a need to systematically map and analyze the intellectual structure and research trends in this emerging domain. This study addresses this gap by conducting a comprehensive bibliometric analysis of virtual museum research to uncover its key themes, influential contributors, and collaborative networks. Data were collected using Scopus advanced search with the keywords "Virtual Museums," "Virtual VR," and "Digital Heritage," yielding a total of 844 documents. The dataset was cleaned and harmonized using OpenRefine to ensure consistency and accuracy. Statistical distributions and trend analyses were performed using Scopus Analyzer, while network visualizations were generated through VOSviewer software to explore co-authorship, co-occurrence of keywords, and country collaborations. The findings reveal a steady increase in publications over the past decade, with significant contributions from China, Italy, and the United Kingdom as leading research hubs. Keyword co-occurrence analysis identified dominant themes such as virtual reality, cultural heritage preservation, interactive experiences, and educational applications. Nine country collaboration clusters were detected, highlighting the global and interdisciplinary nature of this field. Overall, the study provides a structured overview

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of the knowledge landscape, identifies research hotspots, and highlights emerging directions for future work in virtual museum research. These insights not only contribute to the theoretical development of digital heritage studies but also inform practical strategies for enhancing cultural access, preservation, and innovation through technology.

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Keyword:

Virtual Museums, Virtual VR, Digital Heritage

Introduction

Virtual museums have emerged as a transformative force in the realm of cultural heritage, leveraging digital technologies to create immersive and interactive experiences that transcend geographical boundaries. These platforms utilize advanced Virtual Reality (VR) and Augmented Reality (AR) technologies to enable remote access to cultural and historical artifacts, revolutionizing the way these artifacts are exhibited and preserved (Yang et al., 2024) The advent of virtual museums has not only enhanced the accessibility of cultural heritage but also fostered interdisciplinary collaboration and promoted cultural diversity by providing a platform for lesser-known cultures (Yang et al., 2024). Despite the numerous benefits, the widespread adoption of virtual museums faces challenges such as digital disparities, sustainable financial models, and the need for effective user experience design (Yang et al., 2024). This paper aims to explore the current state of virtual museum research, examining technological advancements, user experiences, and the interplay of challenges and opportunities in this evolving field.

The concept of virtual museums has evolved significantly, driven by advancements in information technology and the increasing relevance of cultural heritage virtualization management (Shlyakhetko & Greguš, 2024). Virtual museums are online multimedia applications that use various digital content and implementation technologies to create immersive experiences (Rizvic & Sadzak, 2011). These platforms have become crucial in the conservation of cultural heritage and cultural heritage tourism, especially during the COVID-19 pandemic, which highlighted their importance in providing access to cultural content when physical visits were not possible (Uzun, 2023). The integration of VR and AR technologies in virtual museums has enabled the creation of interactive and engaging experiences, enhancing visitor engagement and access to cultural content (Li et al., 2023). These technologies have also facilitated the development of hybrid three-dimensional virtual museums, which combine

panoramic images and three-dimensional models to create realistic and navigable virtual spaces (Hu et al., 2017).

User experience is a critical aspect of virtual museum design, influencing user satisfaction and cultural participation intentions. Research has identified several visual factors that significantly enhance user satisfaction, including page layout, navigation, information display, color, virtual lighting and shadow, and virtual texture (Yu, 2025). These elements contribute to a more engaging and satisfying user experience, which in turn positively impacts users' motivation to engage in cultural activities within virtual museums (Yu, 2025). Additionally, studies have shown that different user groups, such as clothing design specialists, cultural heritage experts, and general users, have varying experiences and preferences when interacting with virtual museums (Zhang & Zhang, 2025). Understanding these differences is essential for refining the content, interface, and functionality of virtual museums to meet the diverse needs of users (Zhang & Zhang, 2025).

The educational potential of virtual museums is another area of significant interest. Virtual museums have been shown to enhance learning motivation among students by providing immersive and interactive educational environments (Li et al., 2025). Factors such as affective involvement, cognitive engagement, and perceived presence have been found to significantly enhance learning motivation, while elements like perceived enjoyment and interactivity play crucial roles in supporting cognitive processing and engagement (Li et al., 2025). The use of virtual museums in educational settings has also been explored through the lens of museum pedagogy, which emphasizes the role of museums as interactive spaces that engage visitors in dialogue and interaction (Kirillova & Lyapustina, 2023). This approach highlights the potential of virtual museums to transform traditional educational practices and support sustainable digital learning.

Despite the numerous advantages, virtual museums also face several challenges. Digital disparities, particularly in regions with limited internet connectivity, pose significant barriers to access (Yang et al., 2024). Sustainable financial models for the development and maintenance of virtual museums are also a critical concern (Yang et al., 2024). Additionally, the psychological impact of virtual experiences and the potential decrease in real-life tourism are issues that need to be addressed (El Debuch et al., 2024). However, the potential of virtual museums to preserve and promote cultural heritage, enhance user engagement, and support educational initiatives underscores their importance in the digital age. Future research should focus on addressing these challenges and exploring innovative solutions to enhance the effectiveness and sustainability of virtual museums.

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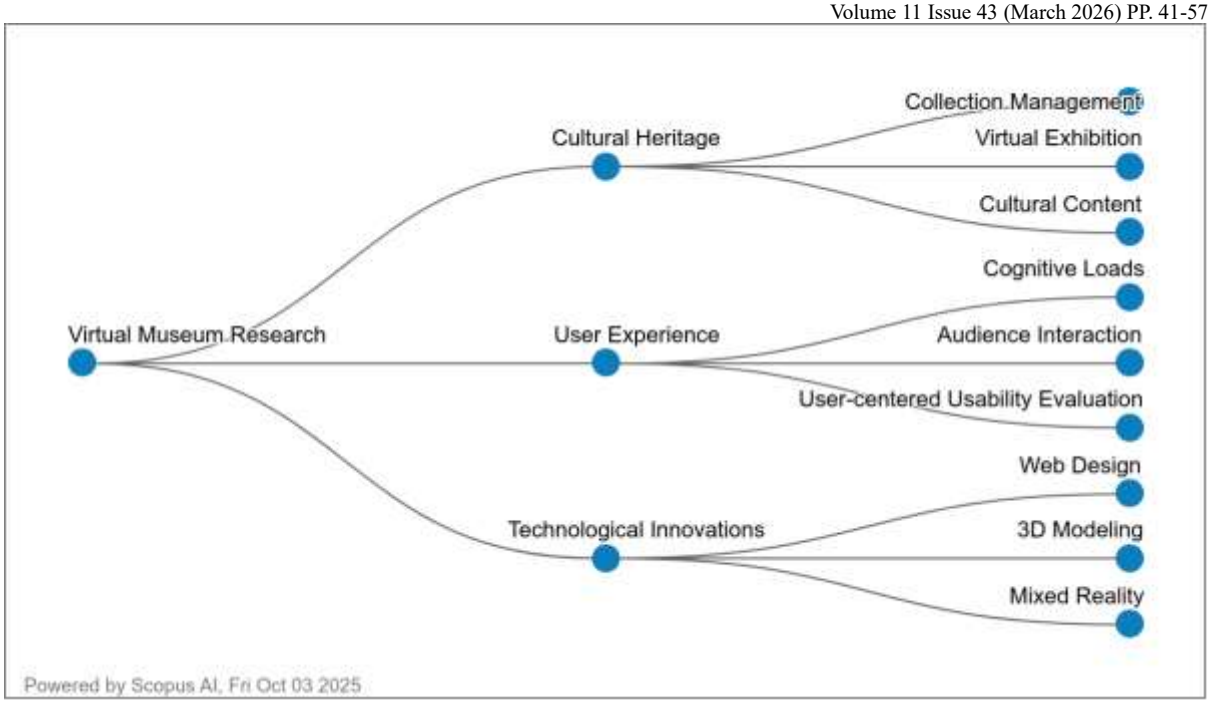

Figure 1: Concept Map for Virtual Museum Research

Figure 1 illustrates a concept map generated by Scopus AI, highlighting the main thematic clusters within Virtual Museum Research. The map reveals three primary domains: Cultural Heritage, User Experience, and Technological Innovations. Under Cultural Heritage, key research areas focus on collection management, virtual exhibitions, and cultural content, emphasizing the role of virtual museums in preserving and presenting heritage materials digitally. The User Experience cluster highlights topics such as cognitive loads, audience interaction, and user-centred usability evaluation, indicating a strong emphasis on enhancing engagement, accessibility, and learning outcomes for diverse audiences. Meanwhile, the Technological Innovations cluster points to developments in web design, 3D modelling, and mixed reality, reflecting the integration of advanced technologies to create immersive and interactive virtual environments. Overall, the concept map underscores how virtual museum research has evolved through the interplay of cultural preservation, user-focused design, and technological advancement, forming a multidisciplinary field that bridges heritage, education, and digital innovation.

In conclusion, virtual museums represent a significant advancement in the preservation and dissemination of cultural heritage, offering innovative solutions to enhance accessibility and engagement. The integration of advanced technologies such as Virtual Reality and Augmented Reality has transformed the visitor experience, allowing for immersive interactions with cultural artifacts that were previously limited by physical constraints. As the body of research on virtual museums continues to grow, it is evident that user experience, educational potential, and technological advancements are critical areas that warrant further exploration. However, the challenges associated with digital disparities, sustainable financial models, and the psychological implications of virtual experiences must be addressed to ensure the long-term viability and effectiveness of these platforms.

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The potential of virtual museums to foster cultural diversity and promote interdisciplinary collaboration is immense, providing opportunities for underrepresented cultures to share their narratives with a global audience. As we move forward, it is essential for researchers, practitioners, and policymakers to work together to develop strategies that enhance the accessibility and sustainability of virtual museums. By doing so, we can ensure that these digital platforms not only serve as repositories of cultural heritage but also as dynamic spaces for learning, engagement, and cultural exchange. Ultimately, the future of virtual museums lies in their ability to adapt to the evolving needs of users and the cultural landscape, making them an integral part of the global cultural heritage ecosystem.

Research Question (5)

RQ1: What are the trends in virtual museum studies that have evolved over time based on annual publication outputs?
RQ2: What are the top ten most highly cited articles that have significantly shaped the field of virtual museum research?
RQ3: What are the countries that demonstrate the highest research productivity in this domain, as reflected by the top ten countries based on publication volume?
RQ4: What are the most frequently occurring keywords that represent the core themes and emerging topics within virtual museum research?
RQ5: What are the international research collaborations structured through co-authorship networks among countries?

Methodology

Bibliometric analysis constitutes a systematic method for collecting, organizing, and examining bibliographic data derived from scholarly publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Rather than merely reporting descriptive statistics—such as publication counts, journal distribution, or prolific authors (Wu & Wu, 2017)—contemporary bibliometric approaches employ advanced analytical techniques, including document co-citation analysis, to uncover structural patterns within a research field. A rigorous literature review process underpins this methodology, involving the iterative refinement of keywords, comprehensive literature searches, and detailed data analysis to ensure both breadth and depth of coverage (Fahimnia et al., 2015). In this study, emphasis was placed on high-impact publications, as these sources offer critical insights into the dominant theoretical frameworks and intellectual structures shaping the domain. To guarantee data reliability, Scopus, a comprehensive and reputable indexing database, was selected as the primary data source (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). Furthermore, to maintain scholarly rigor, only peer-reviewed journal articles were included, with books and lecture notes intentionally excluded (Gu et al., 2019). The dataset encompassed publications spanning 2020 to October 2025 were collected for subsequent analysis.

Data Search Strategy

A systematic search strategy was employed using the Scopus database, selected for its comprehensive coverage of peer-reviewed publications. The advanced search function was used to ensure precision in identifying relevant literature. The following search string was applied: TITLE ((virtual OR VR) AND museum) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, "English")) targeting publications that included the keywords “virtual” or “VR” in combination with “museum” within the title, abstract, or

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keywords. This approach aimed to capture a broad range of studies addressing virtual museums, immersive technologies, and digital heritage practices. The search was conducted in October 2025 to ensure the inclusion of the most recent and relevant publications.

To refine the dataset, clear inclusion and exclusion criteria were applied. Only English-language publications were included to maintain consistency and ensure accurate analysis, while non-English documents were excluded. In terms of timeline, only studies published between 2015 and 2025 were included, focusing on the most current developments in virtual museum research. Publications dated before 2015 were excluded to concentrate on recent technological advancements and contemporary academic discussions, especially in the post-pandemic context where virtual engagement has expanded rapidly.

After applying the search string and screening criteria, the dataset was carefully reviewed to remove duplicates and irrelevant records. This process resulted in a final dataset of 844 documents, comprising journal articles, conference papers, reviews, and book chapters. The selected records were exported in Plaintext format, including essential bibliographic information such as publication year, title, authors, source title, keywords, and citations. This structured search and selection process established a robust foundation for subsequent bibliometric analysis using VOS viewer, including keyword co-occurrence, co-authorship mapping, and thematic clustering.

Table 1: The Search String

Scopus	TITLE ((virtual OR VR) AND museum) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) Access date October 2025

Table 2: The Selection Criterion is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time Line	2015-2025	<2015

Data Analysis

One of VOSviewer's distinctive strengths is its ability to transform complex bibliometric datasets into clear and visually interpretable maps. Emphasizing network visualization, the software supports sophisticated clustering techniques, keyword co-occurrence analysis, and density mapping, allowing researchers to uncover thematic trends and collaborative patterns with ease. Its adaptability to different types of bibliometric data—such as co-authorship and citation networks—positions VOSviewer as an indispensable tool for in-depth research assessment and strategic knowledge exploration.

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For this study, datasets were extracted from the Scopus database in PlainText format, covering publications from 2015 to October 2025. The data included publication year, title, author name, journal, citation counts, and keywords. VOSviewer version 1.6.20 was used to analyze these datasets through clustering and mapping techniques, enabling the systematic generation of visual bibliometric maps. Unlike traditional Multidimensional Scaling (MDS), which relies on similarity measures such as cosine and Jaccard indices, VOSviewer situates items in a low-dimensional space so that the distance between any two items accurately reflects their degree of relatedness (van Eck & Waltman, 2010).While VOS shares conceptual similarities with MDS (Appio et al., 2014), it diverges methodologically by applying a more appropriate normalization approach for co-occurrence frequencies. Specifically, it employs the association strength (AS(_{ij})) measure (Van Eck & Waltman, 2007), defined as:

$$AS_{ij} = \frac{C_{ij}}{w_i w_j}$$

where (C_{ij}) represents the observed number of co-occurrences between items (i) and (j), and (w_i) and (w_j) denote their respective total occurrences. This measure is “proportional to the ratio between, on the one hand, the observed number of co-occurrences of (i) and (j), and on the other hand, the expected number of co-occurrences of (i) and (j) under the assumption that co-occurrences of (i) and (j) are statistically independent” (van Eck & Waltman, 2010, 2017). By applying this approach, VOSviewer provides a more precise and meaningful representation of item similarities, reinforcing its value as a methodological alternative to MDS for bibliometric mapping.

Data Analysis

RQ1: What Are the Trends in Virtual Museum Studies That Have Evolved Over Time Based on Annual Publication Outputs?

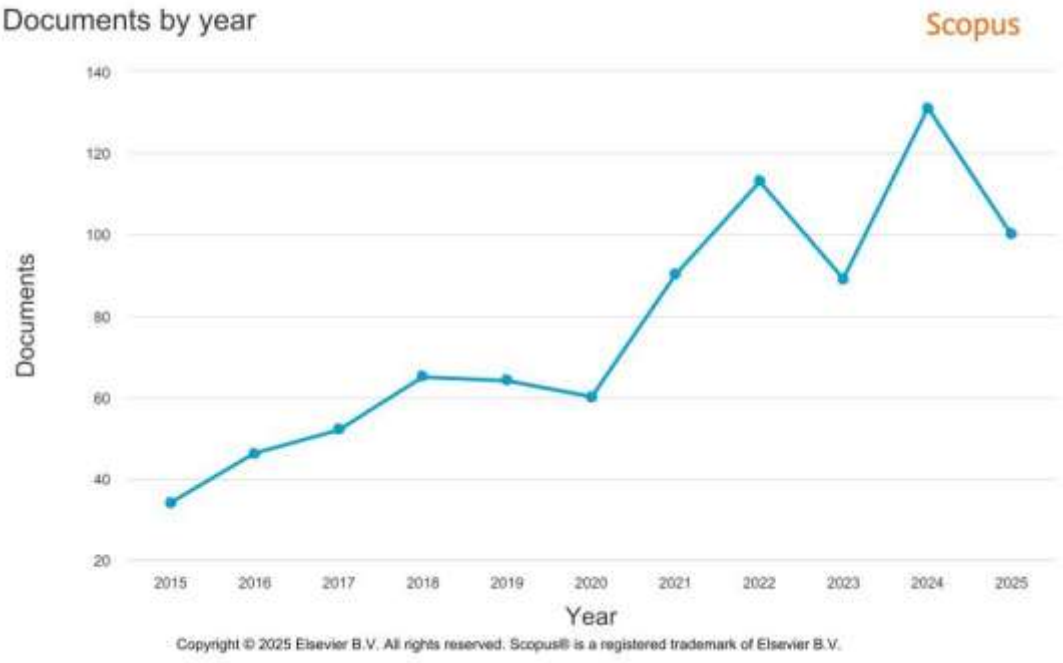

Figure 2: Number Of Documents Based on Year of Publication

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The publication trend from 2015 to 2025 reveals a consistent upward trajectory in research output related to virtual museums, indicating growing scholarly interest and technological advancements in this domain. In 2015, only 34 documents were published, reflecting the relatively nascent stage of virtual museum research at that time. From 2016 to 2019, the number of publications showed steady but moderate growth, rising from 46 to 64 documents. This gradual increase corresponds to the early adoption of digital tools in cultural heritage institutions, as well as the expansion of virtual reality (VR) technologies beyond niche applications into broader educational and museum contexts. A more notable acceleration is observed from 2020 onwards, where publications increased from 60 documents in 2020 to 131 in 2024, peaking at 100 in 2025. This sharp rise illustrates the rapid evolution and integration of immersive technologies, alongside the increased prioritization of virtual engagement strategies within the cultural sector.

Several factors explain this upward trend. The COVID-19 pandemic played a pivotal role, particularly from 2020 onwards, as museum closures worldwide forced institutions to innovate and shift toward virtual platforms for audience engagement, education, and exhibitions. This global digital pivot not only stimulated technological development but also triggered extensive academic inquiry into virtual museum experiences, accessibility, and user interaction. Additionally, the continuous advancement and affordability of VR, AR, and 3D modelling technologies have made virtual museum initiatives more feasible, encouraging interdisciplinary collaborations between technologists, curators, educators, and researchers. The peak in 2024 may also reflect a maturing research landscape, where empirical studies, user experience assessments, and innovative applications became more prevalent, consolidating virtual museums as a significant field of academic exploration. Overall, the publication trend demonstrates both the technological evolution and contextual imperatives that have shaped the growth of virtual museum research over the past decade.

RQ2: What Are the Top Ten Most Highly Cited Articles That Have Significantly Shaped the Field of Virtual Museum Research?

The citation analysis of the top 10 most cited articles highlights the significant academic attention directed toward the integration of virtual and augmented reality (VR/AR) in museums, particularly in recent years. The most cited work, by Lee et al. (2020) with 351 citations, focuses on immersive virtual reality experiences in museums, underscoring the pivotal role of user engagement and technological immersion in shaping contemporary museum practices. Trunfio et al. (2022) follows with 199 citations, examining how VR/AR innovations enhance visitor experiences and satisfaction, while Shehade and Stylianou-Lambert (2020) contribute 184 citations, exploring the perspectives of museum professionals. These highly cited papers share a common focus on visitor experience, professional practice, and immersive technology, reflecting a dominant research theme emphasizing user-centered approaches. Meta-analytic and empirical studies, such as Zhou et al. (2022) with 99 citations, also indicate a growing interest in evidence-based evaluations of VR/AR in educational museum contexts.

The prominence of publications from 2020 onwards reveals a surge in research during and after the COVID-19 pandemic, when digital transformation became a necessity for museums to maintain public engagement. High citation counts for works published between 2019 and 2022 can also be attributed to the rapid adoption of VR technologies, interdisciplinary collaborations, and the publication of these studies in high-impact journals such as *Information and*

Management and *Educational Research Review*. Earlier influential works (e.g., Barbieri et al., 2017; Kersten et al., 2017) remain relevant, as they laid the technical and methodological foundations for subsequent immersive applications, focusing on user studies, system evaluation, and virtual reconstructions. Overall, the citation pattern reflects a shift from technological experimentation to applied, user-focused research, positioning virtual museum studies at the intersection of cultural heritage, technology, and education.

Table 3: Most Cited Author

No	Authors	Title	Year	Source title	Cited by
1	Lee et al., (2020)	Experiencing immersive virtual reality in museums	2020	Information and Management	351
2	Trunfio et al., (2022)	Innovating the cultural heritage museum service model through virtual reality and augmented reality: the effects on the overall visitor experience and satisfaction	2022	Journal of Heritage Tourism	199
3	Shehade & Stylianou-Lambert, (2020)	Virtual reality in museums: Exploring the experiences of museum professionals	2020	Applied Sciences (Switzerland)	184
4	Errichiello et al., (2019)	Exploring the implications of wearable virtual reality technology for museum visitors' experience: A cluster analysis	2019	International Journal of Tourism Research	142
5	Loaiza Carvajal et al., (2020)	Virtual museums. Captured reality and 3D modeling	2020	Journal of Cultural Heritage	121
6	Kersten et al., (2017)	Development of a virtual museum including a 4D presentation of building history in virtual reality	2017	International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives	113
7	Schofield et al., (2018)	Viking VR: Designing a virtual reality experience for a museum	2018		103
8	Barbieri et al., (2017)	Virtual museum system evaluation through user studies	2017	Journal of Cultural Heritage	102

9	Zhou et al., (2022)	A meta-analytic review on incorporating virtual and augmented reality in museum learning	2022	Educational Research Review	99
10	Marín-Morales et al., (2019)	Real vs. immersive-virtual emotional experience: Analysis of psycho-physiological patterns in a free exploration of an art museum	2019	PLOS ONE	91

RQ3: What Are the Countries That Demonstrate the Highest Research Productivity in This Domain, As Reflected by The Top Ten Countries Based on Publication Volume?

Figure 3: Country Mapping Based on Number of Publications

The publication data reveal a clear geographical concentration of research output, with China emerging as the leading contributor to virtual museum research, producing 179 publications. This is followed by Italy (126), the United Kingdom (65), and the United States (55). Greece also demonstrates a notable presence with 53 publications, while Spain, Indonesia, Germany, the Russian Federation, and Thailand contribute between 25 and 30 documents each. This distribution suggests that virtual museum research is driven by both technologically advanced countries and those with strong cultural heritage sectors. China's dominant position reflects its substantial investments in digital innovation, cultural preservation, and technology-driven initiatives. Italy's strong performance aligns with its rich cultural heritage and its active role in integrating digital technologies to preserve and promote historical collections. Similarly, the United Kingdom and the United States, with their well-established research infrastructures and extensive museum networks, have played leading roles in advancing interdisciplinary work at the intersection of heritage, technology, and education.

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Several factors help explain this distribution. China's leadership can be attributed to its strategic national policies promoting digital transformation and the rapid development of immersive technologies, which have catalyzed extensive research and pilot projects in the cultural sector. European countries, particularly Italy and Greece, have leveraged their vast cultural assets to drive virtual museum initiatives, often supported by European Union funding and collaborative research frameworks. The United Kingdom and the United States benefit from robust academic ecosystems and early adoption of digital tools, fostering sustained scholarly output. Meanwhile, countries such as Indonesia and Thailand, although emerging contributors, reflect growing regional interest in digital heritage and educational tourism, supported by increasing access to technological resources and academic collaborations. Overall, the data indicate that virtual museum research is both globally expanding and regionally diversified, shaped by a combination of technological capacity, cultural heritage richness, and institutional support.

RQ4: What Are The Most Frequently Occurring Keywords That Represent The Core Themes And Emerging Topics Within Virtual Museum Research?

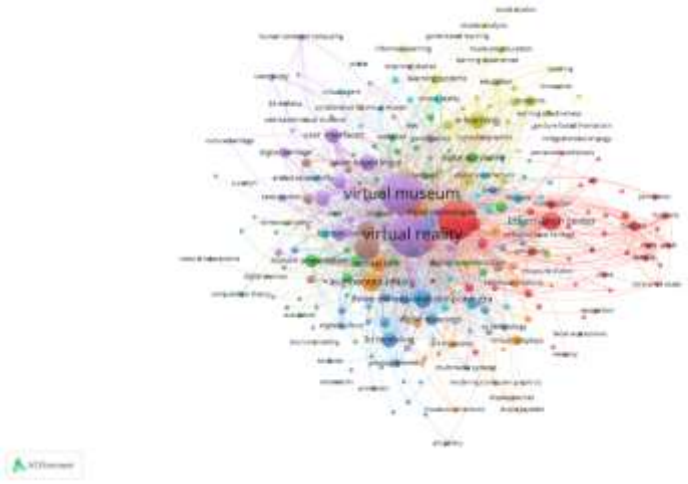

Figure 4: Network Visualization Map of Keywords' Co-Occurrence Of Documents Based on Year of Publication

Co-occurrence analysis of author keywords in VOSviewer identifies patterns of how frequently specific keywords appear together within the same publications, revealing conceptual relationships and research trends within a field. By mapping these co-occurrences, VOSviewer generates network visualizations where nodes represent keywords, and links represent the strength of their co-occurrence. In this analysis, the **full counting method** was applied, meaning each co-occurrence between keywords contributes equally to the total link strength, regardless of how many keywords appear in the same document. A **minimum threshold of 5 occurrences** was set to focus only on keywords with significant frequency, out of a total of 5560 keywords. This filtering resulted in 462 keywords meeting the threshold. To further refine the visualization, a **minimum cluster size of 5** was applied, which grouped related keywords into meaningful clusters. Based on these parameters, the analysis produced **8 clusters**, each representing a distinct thematic area within the research landscape.

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The findings offer substantial contributions to the body of knowledge by highlighting key research themes and their interconnections in the field of virtual museums and immersive technologies. Keywords such as *"virtual reality" (435 occurrences, 2985 total link strength)*, *"virtual museum" (402; 2305)*, and *"museums" (334; 2384)* emerged as central nodes, indicating that these concepts form the core around which other themes are structured. High link strengths suggest strong interdisciplinary connections, particularly with terms like *"interactive computer graphics," "augmented reality," "e-learning,"* and *"user experience."* The presence of diverse clusters, including cultural heritage preservation, educational technologies, user interaction design, and digital storytelling, reflects a rich and evolving research ecosystem. These patterns demonstrate how virtual and augmented reality technologies are being integrated into museum experiences for education, preservation, and user engagement, thereby advancing both theoretical frameworks and practical applications in digital heritage studies.

RQ5: What Are The International Research Collaborations Structured Through Co-Authorship Networks Among Countries?

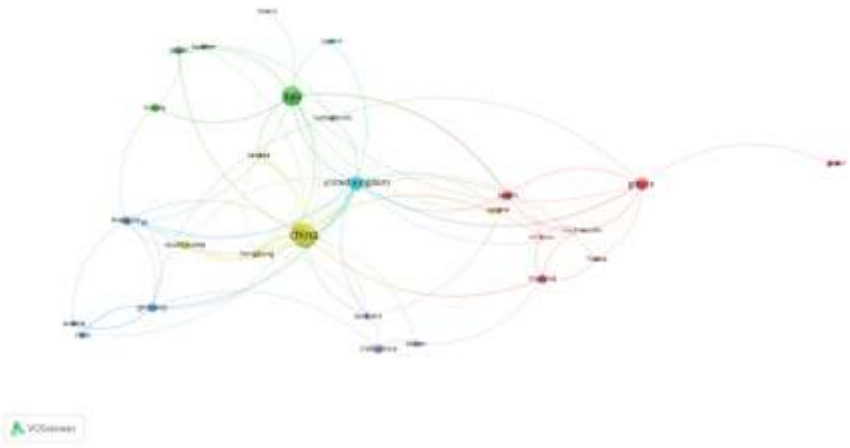

Figure 5: Co-Authorship by Countries' Collaboration

Co-authorship analysis by countries in VOSviewer examines patterns of international research collaboration by mapping how frequently authors from different countries co-publish scientific papers. In this type of network visualization, each node represents a country, and links represent the number and strength of co-authored publications between countries. The size of the node reflects the publication volume, while the thickness of the links indicates the intensity of collaboration. This analysis used the full counting method, where each co-authored paper counts fully for every participating country, giving equal weight to all collaborations. A minimum threshold of 5 publications was applied to include only countries with a substantial level of contribution. Out of 79 countries, 33 met the threshold. A minimum cluster size of 5 was also set, leading to the formation of 9 clusters, each representing groups of countries that frequently collaborate with one another, often reflecting regional proximity, shared research agendas, or strong institutional partnerships.

The results of this analysis highlight the global distribution and collaborative dynamics in virtual museum and immersive technology research. China (183 publications, total link strength 881, links 44) and Italy (124; 1558; 28) stand out as major contributors and central hubs of international collaboration. The United Kingdom also shows high connectivity (65; 1035; 46), indicating its bridging role across multiple clusters. Other countries such as the United States, Germany, Greece, and Thailand show meaningful levels of cooperation, reflecting growing international engagement in this field. The formation of nine clusters signifies diverse but interconnected research communities, spanning Europe, Asia, North America, and emerging collaborations in Southeast Asia and Latin America. These patterns enrich the body of knowledge by illustrating how cross-border partnerships drive innovation, knowledge exchange, and the dissemination of expertise, ultimately strengthening the global research landscape in digital heritage and virtual environments.

Conclusion

The purpose of this study was to systematically map and analyze the intellectual landscape of virtual museum research through bibliometric techniques. The analysis was designed to address key questions related to publication trends, highly cited works, leading contributing countries, dominant research themes, and patterns of international collaboration. By applying bibliometric methods to data extracted from the Scopus database, the study aimed to provide a structured overview of the development and current state of this evolving research domain.

The findings reveal a clear and consistent increase in research output from 2015 to 2025, indicating growing academic attention toward virtual museums, especially during the period following the COVID-19 pandemic. The citation analysis highlights influential publications focusing primarily on immersive technologies, user experience, and educational applications, which have shaped contemporary discourse in the field. Geographically, China, Italy, and the United Kingdom emerge as dominant contributors, while keyword co-occurrence analysis shows that “virtual reality,” “virtual museum,” and “museums” form the conceptual core, surrounded by themes such as cultural heritage preservation, interactive technologies, and educational innovation. Collaboration analysis demonstrates the presence of multiple international clusters, reflecting a diverse yet interconnected research community across regions.

This study contributes to the field by offering a comprehensive overview of research patterns, thematic structures, and collaborative linkages that define virtual museum studies. It consolidates fragmented knowledge and identifies emerging directions, enabling a deeper understanding of the intellectual foundations and evolving priorities in this domain. The insights generated provide valuable references for scholars, practitioners, and policymakers interested in digital heritage, cultural preservation, and technology-enhanced learning.

The findings carry practical implications for the development and implementation of virtual museums in real-world settings. By identifying active research hubs, influential themes, and collaborative networks, the study offers a useful basis for strategic planning, partnership development, and technological innovation within cultural institutions and academic environments.

Nevertheless, some limitations remain. The analysis was restricted to publications indexed in Scopus and written in English, which may exclude relevant studies in other databases or languages. Additionally, while bibliometric methods provide valuable quantitative insights, they do not capture the full depth of conceptual developments or qualitative perspectives. Future research could expand coverage to additional databases, incorporate mixed-method approaches, and explore longitudinal thematic evolution in greater detail.

Overall, this study underscores the importance of bibliometric analysis as a tool for understanding the structure and dynamics of research in virtual museums. By illuminating key trends, influential works, and collaborative patterns, it lays the groundwork for more informed research, practice, and policy development in this rapidly expanding field.

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Author Contribution Statement: All authors contributed substantially to the conception and development of this study. The 1st author led the conceptualization of the research, designed the bibliometric framework, supervised the overall study, and guided the interpretation of findings. The 2nd author was responsible for data collection from the Scopus database, data cleaning, and bibliometric analysis using VOSviewer, including co-authorship, citation, and keyword co-occurrence analyses. The 3rd and 4th authors conducted the literature review, drafted the manuscript, and contributed to data interpretation and critical revision of the paper. All authors reviewed and approved the final manuscript prior to submission.

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