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Digital Humanities and Immersive Technologies: A Bibliometric Analysis

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Abstract

This study investigates the intersection of immersive technologies and Digital Humanities through systematic review and bibliometric analysis. Data from the Web of Science were analyzed using VOSviewer to produce visual maps of keyword co-occurrences, thematic clusters, author collaborations, and publication trends. Five major clusters emerged: effect, performance, systematic review, motivation, and user experience, with effect identified as the most influential theme, often linked to

performance, motivation, and evaluation. The results suggest a strong focus on how immersive and interactive technologies shape learning, engagement, and user outcomes. Author network analyses highlighted recurring collaborations led by Wu J.L., Ren Z.B., Monteiro C.B.D., and Liu J., while publication trends showed steady growth after 2015. Country-level insights revealed significant contributions from China, the United States, Canada, South Korea, and England, reflecting the field's global expansion and growing scholarly interest. The findings highlight how research in immersive technologies and Digital Humanities has evolved.

Keywords: Virtual Reality, Augmented Reality, Digital Humanities, Intelligent Interfaces, Systematic Literature Review, Bibliometric Analysis.

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1. INTRODUCTION

Digital humanities is widely understood as an area of scholarly activity that brings digital technologies and computational methods into dialogue with humanities disciplines, supporting new ways of analyzing, curating, and presenting cultural and textual materials (Berry, 2012). In recent years, digital humanities have undergone a rapid transformation as immersive and interactive technologies, including virtual reality, mixed reality, and intelligent interfaces, have become central to clinical research, pedagogy, and cultural engagement. These advancements have led to an increasing focus on how such technologies shape user experience (UX), influence learning outcomes, and contribute to broader scholarly practices. As the volume of publications grows, understanding how research themes develop and how different areas connect has become an essential part of examining the field's evolution.

Despite the rapid growth of research on immersive technology in the digital humanities, literature remains fragmented and dispersed. The field lacks a unified narrative, with studies originating from disparate domains ranging from clinical rehabilitation to cultural heritage. This fragmentation makes it difficult to determine which areas represent the strongest concentration of activity or how key concepts like performance and UX interact over time. Without an organized, cohesive structure, the intellectual landscape remains a collection of isolated findings rather than a maturing discipline. This study employs network mapping and keyword clustering to synthesize these diverse contributions into a clear, grounded overview of the field's progression.

The objective of this study is to map the intellectual structure of immersive technology research within the digital humanities domain. Using VOSviewer for visual analytics and clustering, the analysis identifies dominant thematic clusters, including effect, performance, systematic review, motivation, and user experience. The scope of this research is defined by a dataset curated from the Web of Science, focusing specifically on publication titles to reveal the explicit thematic focuses of literature. This title-based extraction provides a refined lens to review the progression of research topics and collaborative relationships across different regions and time periods. These insights enable researchers to align their work with existing trends and identify opportunities for future study.

2. RESEARCH BACKGROUND

Digital humanities represent a robust interdisciplinary field situated at the intersection of computing and traditional humanistic inquiry. Research in digital humanities often encompasses a diverse "array of convergent practices" (Burdick et al., 2016). The integration of immersive technologies into digital humanities has expanded steadily over the past decade, transitioning from experimentation to a robust interdisciplinary discourse. Scholars across education, cultural heritage, healthcare, and interface design have explored how virtual reality and intelligent interfaces enhance user engagement and learning (Radianti et al., 2020). Early studies highlight how immersive environments improve motivation, deepen understanding, and support hands-on learning experiences by situating users within dynamic digital contexts. As research grew and matured, recurring themes such as effect, performance, and motivation appear frequently across publications, reflecting a shared focus on understanding how immersive technologies influence user outcomes rather than simply describing their technical features (Makransky & Lilleholt, 2018). Over time, these themes evolved into broader consolidations of usability, interaction quality, and the experiential dimensions of digital systems.

A notable trend in recent years is the rise of systematic reviews and evidence-synthesizing approaches aimed at consolidating findings across diverse studies. As virtual and mixed reality applications became widespread, researchers increasingly adopted structured methodologies, such as systematic reviews

and meta-analyses, to assess effectiveness, identify methodological patterns, and expose gaps in existing work. These studies often examine learning outcomes, cognitive engagement, rehabilitation performance, and usability measures, signaling a shift from exploratory designs toward more formalized, evaluative frameworks. The growing presence of such synthesis in the bibliometric network indicates that immersive-technology research is maturing into a field that values methodological rigor and longitudinal validation. This bibliometric study differs from prior work by explicitly focusing on the intersection of digital humanities and immersive technologies rather than treating either as separate domains, thereby mapping how these two areas co-evolve within a single, integrated intellectual landscape.

Furthermore, user experience (UX) has evolved as a primary research pillar, in which scholars highlight how interface design, immersion, and presence shape the emotional and cognitive dimensions of the user journey (Hassenzahl & Tractinsky, 2006). Evaluations of virtual and mixed reality systems now prioritize UX metrics to determine how participants interpret digital content, navigate virtual spaces, and respond to different levels of interactivity (Makransky & Lilleholt, 2018). This transition reflects a broader recognition that technological performance alone is insufficient, and that meaningful engagement depends on how users experience and interact with the environment.

The authorship landscape reveals robust collaborative networks. Researchers such as Wu J., Ren Z., Kim C., and de Mello Monteiro C. B. have played key roles in steering the field's evolution. Their interdisciplinary work spans multiple domains, underscoring the shared interest in assessing user outcomes, educational value, and interaction quality. These collaborations signal the presence of active research communities that sustain thematic coherence and methodological advancement.

Geographically, research priorities differ across regions. China has become a leader in large-scale, performance-oriented studies, often supported by national strategic funding. In contrast, North American institutions tend to emphasize cognitive engagement and user experience, while European researchers frequently integrate cultural heritage and interface design. Such regional patterns demonstrate how local priorities and institutional supports shape the global trajectory of digital humanities research.

In summary, while immersive technologies have significantly enriched the digital humanities, the resulting literature remains a rich but scattered landscape. Individual studies contribute valuable insights within their specific domains, yet their dispersion across fields hinders a comprehensive understanding of the field's evolution. By organizing these contributions through bibliometric analyses (publication trend, geospatial distribution, keyword co-occurrences), this study provides the integrated structure necessary to trace how immersive technologies continue to redefine the research domain.

3. RESEARCH METHOD

3.1 Data Collection and Search Strategy

Web of Science and Scopus are two major databases used for scientific literature searches, as they cover a wide range of disciplines. However, Scopus primarily covers the social sciences, whereas Web of Science covers the natural sciences, engineering, and arts & humanities (Kumpulainen & Seppänen, 2022). Thus, we selected Web of Science as the search repository for this study. The dataset for this study was retrieved in March 2025 from the Web of Science Core Collection, a recognized resource for comprehensive indexing of peer-reviewed scholarly literature. To identify research situated at the intersection of intelligent interfaces and Digital Humanities, we executed the following advanced search query:

(ALL=(humanities research) OR ALL=(Digital humanities)) AND (ALL=(novel user interfaces) OR ALL=(Mixed Reality) OR ALL=(Virtual Reality) OR ALL=(Augmented Reality) OR ALL=(Intelligent Agent))

This query returned 1,538 records. Due to the platform's 1,000-record export constraint, the dataset was downloaded in two batches as RIS files and subsequently merged into a single unified corpus for analysis. The query was restricted to English-language articles, and no publication-year criteria were set. The query was conducted in September 2025.

3.2 Data Refinement

An initial exploratory analysis incorporated keywords extracted from titles, abstracts, and metadata. However, this approach produced a dense and highly interconnected network, complicating the identification of distinct thematic clusters. Much of this complexity stemmed from linguistic "noise" in abstracts, which often included descriptive or contextual phrasing that did not reflect a study's primary focus. To achieve greater conceptual clarity, the analysis was refined to include only terms from article titles, thereby emphasizing core research themes rather than peripheral content.

3.3 Bibliometric Tool: VOSviewer

VOSviewer was selected for its robust capacity to construct and visualize bibliometric networks, including co-authorship and keyword co-occurrence mappings. The software applies clustering algorithms to detect thematic groupings and represents these relationships through an intuitive graphical interface, where node size, color, and link strength communicate significance and emerging trends. In VOSviewer, Total Link Strength (TLS) represents how strongly an item (such as a keyword, author, or country) is connected to other items in the network, based on the cumulative strength of all its co-occurrence or co-citation links. VOSviewer's versatility makes it particularly effective for bridging interdisciplinary domains such as Digital Humanities and Virtual Reality, enabling fragmented literature to be translated into cohesive visual narratives. The platform's dynamic filtering functions further support fine-grained exploration of local structures within the dataset.

3.4 Data Processing and Normalization

The merged RIS dataset was imported into VOSviewer, employing the Title field for term extraction. To ensure the integrity of the resulting maps, we used the "Verify selected terms" interface to inspect both occurrence frequencies and relevance scores. A thesaurus file was then developed to consolidate synonymous or redundant expressions (e.g., aligning "VR," "virtual-reality," "virtual reality technology," "immersive virtual reality," "virtual," and "virtual reality" under a single standardized term). This normalization process, implemented through VOSviewer's two-column mapping format, effectively minimized lexical noise and enhanced the consistency and interpretability of keyword clusters.

4. FINDINGS

4.1 Publication Trends Between 1995 and 2025

To evaluate the publication trend of digital humanities and intelligent systems, we analyzed the number of publications from 1995 to 2025. As shown in Figure 1, scholarly activity remained marginal between 1995 and 2010, characterized by sporadic contributions. A notable shift began around 2013, coinciding with the emergence of digital learning, immersive technologies, and human–technology interaction as core research interests. Building on this momentum, the field experienced an exponential surge in publication volume between 2019 and 2025, during which annual output surpassed 300 papers in 2024. Such sustained growth highlights accelerating research interest and the increasing viability of VR/AR technologies for digital humanities. This rapid acceleration of publication efforts reflects a thematic expansion toward effect, performance, user experience, artificial intelligence, metaverse, and systematic review. Furthermore, this upward trajectory aligns with the global digital transformation and the post-pandemic reliance on intelligent systems, signaling a transition for this domain into a highly active, fast-growing research field.

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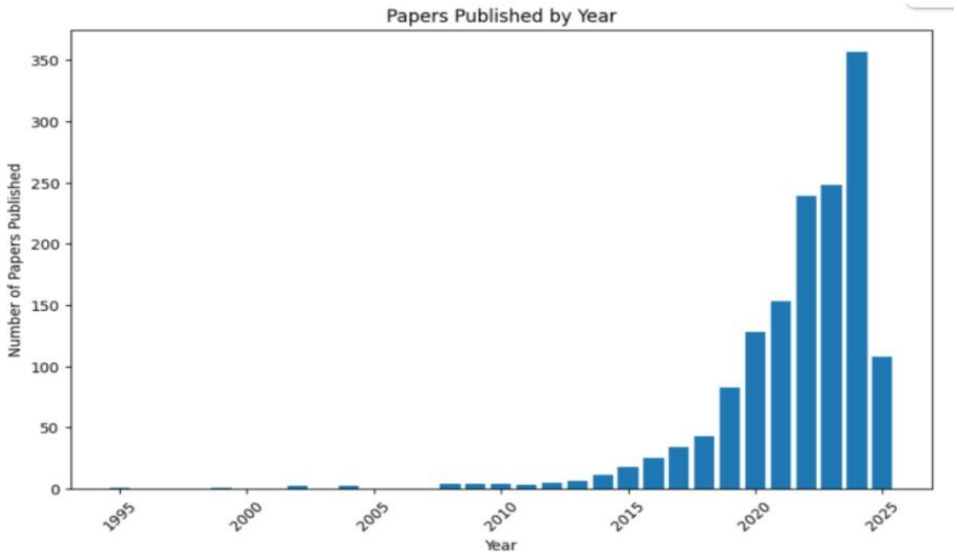

Figure 1: The Growth of Research Publications Over Time (1995-2025)

4.2 Global Distribution of Publications

Figure 2 presents the geospatial distribution of research contributions from the dataset. The map shows publication density through varying shades of blue, with darker tones indicating higher scholarly output. As illustrated, China emerges as the global leader with 1,147 publications, underscoring its dominance in artificial intelligence, virtual reality, and educational technology. Other regions, including the United States, Canada, South Korea, Australia, and parts of Western Europe, exhibit moderately dark shading, indicating robust and consistent research activity. Conversely, lighter shades across much of Africa, the Middle East, and South America reveal lower contribution levels. The resulting map confirms that the research topic has garnered worldwide interest and highlights a significant concentration of output in regions with advanced technological and academic infrastructure.

Figure 2: Global Distribution of Publications Across Countries

4.3 Keyword Co-Occurrence Analysis

Using VOSviewer, we produced the keyword co-occurrence network shown in Figure 3, which reveals five focused thematic clusters with significantly strong conceptual connections. These clusters are well-defined and clearly illustrate the direct interactions between core research themes. The following

analysis details the thematic structure of the research field based on a title-based keyword co-occurrence network. The network is organized into clusters that represent distinct yet interconnected research orientations, ranging from methodological synthesis to applied interventions.

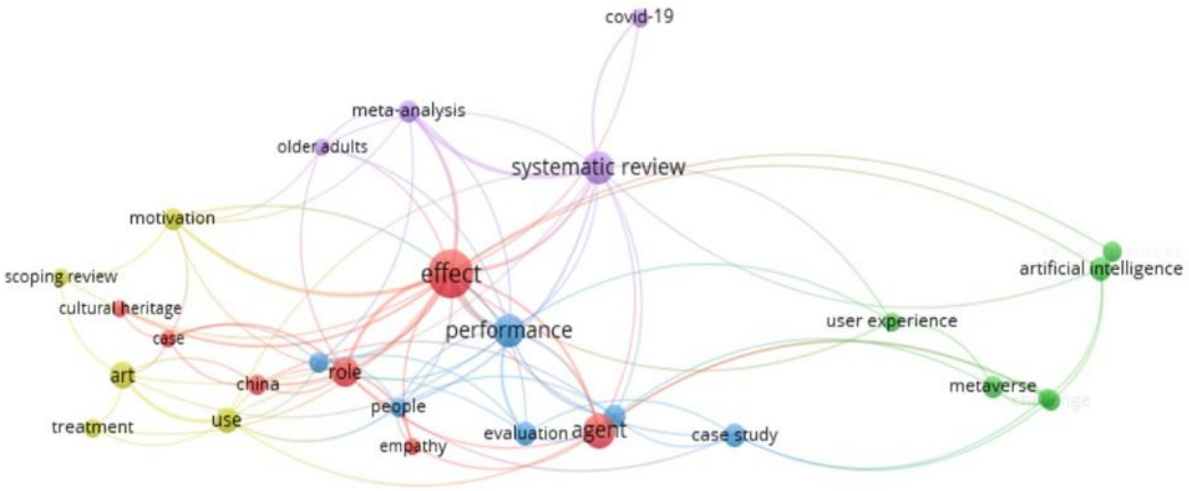

Figure 3: Title-based Keyword Co-occurrence Analysis

4.4 The Macro Network: "Effect" as the Primary Driver

As illustrated in Figure 3, "Effect" emerges as the most prominent and influential node, appearing 88 times with a total link strength (TLS) of 50. It functions as the central bridge for the entire network, maintaining the highest number of connections across all clusters, specifically linking with "performance", "systematic review", "motivation", and "agent". The dominance of this node indicates that the primary objective of current literature is to evaluate the impact of immersive and interactive technologies on learning, behavior, and user experience. High co-occurrence values between "performance" and "use" indicate a field-wide priority for measuring how technology improves task outcomes or interaction quality. As the central node, "effect" facilitates the integration of evidence-based research, human-centered outcomes, and emerging technologies like artificial intelligence and the metaverse.

4.5 Red Cluster: Socio-Emotional and Agent-Based Interactions

The red cluster encompasses research describing how technological interventions influence human behavior, cultural contexts, and emotional responses.

Intra-cluster Dynamics:

- Effect as the Central Node: Within the red cluster, Effect acts as the primary thematic core. The internal logic of this cluster suggests that research is heavily preoccupied with the Agent and Role of technology in social mediation.
- Virtual Agents and Roles: Agent (59 occurrences, 10 co-occurrences with effect) and Role (39 occurrences, 5 co-occurrences with effect) are two dominant themes. Research in this node evaluates how virtual agents or AI tutors affect learning and engagement, and examines how teachers, virtual agents, and learners shape technology-driven outcomes.
- The Emotional Dimension: Nodes such as Cultural Heritage (24 occurrences) and Empathy (14 occurrences) indicate that this research focuses on emotional or experiential responses triggered by immersive environments. In heritage studies, the "effect" being measured is often the depth of historical immersion and emotional resonance.
- Key Authors and Papers: The analysis of the dataset shows that Wu, J., and Ren, Z. appear most frequently in titles containing the keyword "effect", suggesting a strong and consistent research focus on evaluating how virtual reality technologies influence human performance, rehabilitation, and social development. Their work spans multiple high-impact studies, each emphasizing

measurable outcomes and supported by systematic review or meta-analysis methodologies (Ren & Wu, 2019; Wu et al., 2019; Wu et al., 2021; Yang et al., 2025)

Inter-cluster Analysis:
- Red-Purple (Impact to Synthesis): The prominent linkage between Effect (Red) to Systematic Review (Purple) constitutes the strongest inter-cluster link in the network, suggesting that synthesis methods are primarily employed to analyze behavioral effects across studies.
- Red-Blue (Behavior to Performance): The connection between Agent (Red) and Performance (Blue) signifies a research focus on applied evaluations that measure how technologies impact behavior, task outcomes, and user performance.

The Red Cluster defines the experiential and sociocultural impact of technology, focusing on the roles of agents and the cultural heritage context to evaluate emotional and social impact.

4.6 Blue Cluster: Applied Evaluation and Real-World Outcomes

Evidence-based and outcome-oriented studies characterize the blue cluster. It focuses on measuring how technologies perform in practical, real-world, or experimental settings.

Intra-cluster Dynamics:
- Performance as the Central Node: Performance (48 occurrences) is the anchor of this cluster and one of the most outcome-driven nodes in the entire network. It serves as the core indicator for validating the effectiveness of digital tools.
- Evaluation and Validation Methods: The presence of Evaluation (22 occurrences, TLS 8) and Case Study (20 occurrences, TLS 3) indicates a reliance on real-world examples to assess the effects of specific settings, such as classrooms or clinics.
- Key Authors and Papers: da Silva, T. D., and de Mello Monteiro, C. B. are the key figures within the blue cluster. Their work examines how virtual games or non-immersive virtual reality tasks can be used to assess and improve motor performance in people with neurological movement disorders, and how practice in these environments supports motor learning and potential transfer to other tasks (de Paula et al., 2018; Graciani et al., 2024; Martins et al., 2019). Across those publications, performance is treated as the central indicator of improvement to assess whether immersive technologies meaningfully enhance task accuracy, coordination, and functional ability.

Inter-cluster Analysis:
- Blue-Purple (Outcomes to Synthesis): There is a strong pipeline between Performance (Blue) and Systematic Review (Purple), showing that individual performance-based studies are frequently aggregated into high-level evidence syntheses. Additional connections exist between Performance and Meta-Analysis, and between Performance and Older Adults, likely exploring how aging populations respond to technology-based training or rehabilitation and quantifying overall performance outcomes across multiple experiments.
- Blue-Green (UX to Outcomes): The link between Performance (Blue) and User Experience (Green) is vital. Those studies examine how usability, immersion, and interaction quality affect performance outcomes.

The Blue cluster provides the empirical evidence for the field, grounding technological potential in measurable human performance.

4.7 Purple Cluster: Evidence Synthesis and Methodological Integration

The purple cluster represents the methodological foundation of the dataset. This cluster focused on how systematic evidence strengthens the understanding of technological outcomes across diverse settings.

Intra-cluster Dynamics:
- Systematic Review as the Central Node: Systematic Review (41 occurrences) is the central anchor. Its prominence indicates that the field has reached a stage of maturity in which researchers are consolidating data rather than just exploring new ideas.

- Methodological Pillars: Meta-analysis (18 occurrences) and COVID-19 (17 occurrences) are key nodes. This cluster highlights how researchers have synthesized the impact of digital tools during the pandemic and for specific groups, such as Older Adults (4 occurrences).
- Key Authors and Papers: Wu, J., is the most prolific author in this methodological space. Wu's work, including reviews on VR training for stroke patients and children with cerebral palsy, demonstrates a strong commitment to evidence-based evaluation within immersive technology research. This body of work strengthens the reliability of findings in virtual reality rehabilitation and provides a structured foundation for advancing digital health and educational interventions (Wu et al., 2019; Wu et al., 2021; Yang et al., 2025).

Inter-cluster Analysis:
- Purple-Green (Innovation to Synthesis): There is a link connecting Systematic Review (Purple) to Artificial Intelligence (Green). This link points to a growing body of literature that reviews and consolidates the efficacy of AI-driven tools across various applied contexts. In addition, the link between Systematic Review and User Experience represents a research pipeline that examines how UX factors (such as design, usability, and interaction quality) shape user engagements.
- Purple-Yellow (Synthesis to Mapping): The yellow cluster combines psychological, exploratory, and intervention-based themes. The links between Systematic Review (purple) and Use (Yellow), and between Meta-analysis (purple) and Motivation (yellow) reveal a research set that maps existing evidence, identifies research gaps, and evaluates behavioral and clinical outcomes of digital tools.

The Purple cluster ensures the scientific rigor of the field, providing a methodological foundation for advancing digital health and educational interventions through rigorous synthesis.

4.8 Yellow Cluster: Psychological Dynamics and Methodological Mapping

This yellow cluster groups psychological drivers, such as motivation and exploratory reviews (scoping reviews), and specific applied contexts, such as art and therapy. It seeks to understand the "why" of technology adoption and how these tools are used as clinical "treatments".

Intra-cluster Dynamics:
- Motivation as the Central Node: Motivation (23 occurrences) is the anchor node in the yellow cluster. Its central position shows that researchers frequently examine how motivational factors influence user engagement, participation, and learning within digital and immersive environments. Rather than being a standalone psychological concept, motivation is connected across clusters, indicating that it plays an important role in explaining why users persist, interact, or respond positively in technology-supported contexts. Overall, the prominence of motivation highlights the field's interest in understanding the psychological dynamics of user engagement and behaviors.
- Specific Applications: "Treatment" (16 occurrences) highlights clinical or rehabilitation outcomes, while "Scoping review" (12 occurrences) maps research gaps. The node "art" also appears here, representing specific applied contexts for cultural learning. "Use" is another hub (23 occurrences) of this cluster, connecting "treatment" and "art" to the central node and serving as a bridge that links these specialized inputs (art/treatment) to the central outputs (effect/performance).
- Key Authors and Papers: Kim, C., Harley, J. M., and Lajoie, S. P. are the key authors in this cluster. Their work focuses on the "emotion-aware" learning environments, exploring how emotional responses and interface design influence cognitive engagement and long-term motivation. They argue that for a digital "effect" to occur, the user must first be emotionally "motivated" to participate (Belland et al., 2013; Harley et al., 2017; Kim, 2012).

Inter-cluster Analysis:
- Yellow-Red (Motivation to Effect): The connection between motivation (yellow) and effect (red) reflects a set of studies examining the effect of digital tools on motivation in learning or interactive settings. In addition, the link between motivation (yellow) and role (red) examines how a tool's functional role stimulates the user's drive to engage.
- Yellow-Blue (Motivation to Performance): A subtle link exists between motivation (yellow) and performance (blue). These co-occurrences (TLS 2) explore how affective factors, such as user drive, influence the ultimate accuracy and success of a digital intervention.

The Yellow cluster addresses the field's breadth in psychology and methodology, positioning motivation as a key mediator of learning outcomes and technological effectiveness. Taken together, the intra- and inter-cluster patterns point to a research trend in which motivation and affect are treated as central mediating mechanisms that link the functional role and "effect" of immersive digital tools to users' engagement and performance outcomes, especially in digital humanities–related contexts such as art-based cultural learning and clinically oriented "treatment" uses of immersive experiences.

4.9 Green Cluster: User Experience, Artificial Intelligence, and Metaverse

The Green Cluster represents the frontier of the field, focusing on emerging artificial intelligence (AI) systems and user experience quality. Key themes include user interaction quality, the integration of AI into learning environments, and the exploration of the Metaverse.

Intra-cluster Dynamics:

- User Experience as the Central Node: User Experience (22 occurrences) is the strongest and most connected node in this cluster. It is treated as the primary factor influencing satisfaction and interaction quality across immersive environments. Its prominence indicates that researchers consistently examine how users perceive, interact with, and respond to digital systems. The prominence of user experience underscores the importance of understanding how users feel and behave within digital interfaces to improve design, enhance immersion, and support effective learning and performance.
- Innovation Drivers: "Artificial intelligence" is another major theme, exploring how AI-driven systems influence decision-making and adaptive learning. The "metaverse" (5 occurrences) is also emerging in this cluster, specifically linked to user experience. This node reflects a growing interest in evaluating spatial navigation and presence shape engagement within virtual ecosystems.
- Key Authors and Papers: In the green cluster, the prominent researchers include Banakou, D., Slater, M., Kim, Y. M., and Liu, K. Their work consistently converges on the central pillar of user experience. This shared focus reveals a broader academic movement to understand how individuals perceive and interact with immersive digital environments across specialized contexts (Kim et al., 2020; Liu et al., 2023; Slater et al., 2022).

Inter-cluster Analysis:

- Green-Red (UX to Effect): User experience (Green) is linked to the network's central hub (Effect, Red). This cluster relationship indicates that user experience design quality is a prerequisite for achieving significant behavioral or social impacts. There is a clear link connecting the Metaverse node (green) to the agent node (red), indicating that research in the Metaverse is heavily focused on the use of virtual agents as the primary mechanism for user interaction.
- Green-Yellow (No direct connection): There is no direct keyword co-occurrence link between the green cluster and the yellow cluster. Instead, the research on user experience (green) is mediated through the central hubs of the red (effect) and purple (systematic Review) clusters. Specifically, the connection to motivation (yellow) is facilitated by the red cluster's focus on experimental effects. Likewise, the link to use (yellow) is established through the purple cluster's role in systematic reviews.

The green cluster highlights future-oriented research, positioning UX and AI as essential components for the next generation of immersive digital environments. Although the current dataset does not yet show a distinct cluster around large language models or generative AI, the prominence of AI-driven user experience research in the green cluster suggests clear opportunities for future studies to examine how emerging LLM-based agents and generative interfaces may further reshape interaction quality and immersive digital humanities environments.

5. Discussion

5.1 Summary of Findings

The findings from this study reveal distinct patterns in global publication activity and thematic development within the research on immersive technologies, digital learning, and human–technology interaction. Since 2019, the keyword network has shown a significant centralization of terms such as effect, performance, systematic review, motivation, and user experience. This structural centralization

reflects a broader digital transformation, accelerated by the expansion of remote learning and the integration of AI-driven systems, as research has shifted from technical feasibility to the validation of human-centered outcomes.

Several systemic factors, including substantial government investment in artificial intelligence and the rapid integration of virtual reality frameworks across education and healthcare, underpin China's leading position in this landscape. Furthermore, strong university–industry partnerships in China have facilitated large-scale projects, allowing for the sharp rise in publication volume observed through 2025. In contrast, the global landscape remains "long-tailed," with many universities worldwide contributing specialized, niche research in areas such as clinical virtual reality or user experience evaluations. The occasional appearance of hospitals and medical institutions in the dataset suggests overlap between clinical studies and digital rehabilitation or immersive therapy.

A key observation is that the most frequent keywords align with growing academic interest in evaluating how immersive technologies affect real-world learning and behavior. The field is clearly evolving from descriptive studies toward evidence-based, outcome-driven, and user-centered research. Additionally, the emergence of themes such as the metaverse, virtual agents, and artificial intelligence signals a pivot toward next-generation digital ecosystems.

5.2 Limitations

This study has several limitations. First, it relies on a single bibliographic database (Web of Science), which may omit relevant publications indexed elsewhere, thereby constraining coverage of AR/VR and digital humanities work. Second, the analysis is based on article titles only, which do not fully capture the conceptual depth, methodological detail, or contextual nuances present in abstracts and full texts, so topic identification and thematic mapping may under-represent complex or oversimplify interdisciplinary contributions. Third, as a bibliometric study, the findings reflect patterns in publication practices rather than direct evidence of practice-level impact or user outcomes, and are therefore sensitive to well-known limitations of bibliometric indicators. Finally, potential citation and indexing biases, such as preferential coverage of certain languages, regions, venues, or disciplines, may shape the observed intellectual structure and should be considered when interpreting the results.

5.3 Implications for Future Research

Looking forward, the findings highlight a critical need for longitudinal research. While many studies effectively measure short-term learning outcomes or immediate performance, there is a lack of data tracking long-term behavioral change or sustained engagement. Prioritizing longitudinal methodologies would strengthen the field by demonstrating how immersive technologies influence users over extended periods and enable more robust data collection from long-term projects.

Furthermore, the connectivity gap between the green cluster (UX, AI, and Metaverse) and the yellow cluster (psychological dynamics) warrants interdisciplinary attention. Future studies are needed to bridge this gap by investigating how specific AI technologies and Metaverse features directly catalyze user motivation. By bridging these disparate clusters, scholars can develop a more holistic model. Such an approach would prioritize integrating interface design and interaction quality, ensuring that the next generation of immersive technologies is not only technically sophisticated but also capable of fostering long-term user satisfaction.

6. CONCLUSIONS

In summary, this bibliometric study demonstrates how network-based keyword analysis and cluster visualization can systematically map the intellectual structure of work at the intersection of digital humanities and immersive technologies, rather than relying on ad hoc narrative reviews. The co-occurrence analysis shows how themes such as motivation, user experience, effect, performance, AI, and the metaverse are positioned and connected within the corpus, providing an evidence-based view of how the field is organized and evolving. The thematic connections identified through keyword analysis highlight the central role of user experience and longitudinal impact in current scholarship, suggesting that by adopting long-term methodological frameworks and prioritizing human-centered design, researchers can move beyond the "novelty effect" of immersive technology to establish more

sustainable, impactful, and integrated digital ecosystems. By foregrounding the strengths and limits of a title-based, single-database bibliometric approach, this study offers a replicable methodological template that other researchers can adapt to track future developments in immersive digital humanities, including the emergence of new thematic clusters as technologies and scholarly practices continue to evolve.

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