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A WEB OF SCIENCE-BASED BIBLIOMETRIC PERFORMANCE ANALYSIS OF IMMERSIVE AND INTERACTIVE TECHNOLOGIES IN CULTURAL HERITAGE, MUSEUMS, AND CULTURAL TOURISM

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Abstract:

Immersive and interactive technologies are changing how cultural heritage is documented, interpreted, and experienced. Virtual reality (VR), augmented reality (AR), mixed reality (MR), virtual museums, and mobile heritage applications now feature across cultural heritage sites, museums, and cultural tourism destinations. Although research in this area has grown rapidly, no bibliometric study guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) has systematically mapped its scientific productivity, scholarly influence, and multidisciplinary structure using the Web of Science (WoS) Core Collection. This study maps the intellectual landscape of the field by identifying the most productive authors, institutions, countries or regions, and journals, together with the most cited publications and the research-area distribution. A PRISMA 2020-guided bibliometric performance analysis of the WoS Core Collection was conducted, with a four-stage screening process retaining 726 English-language articles and early-access records published between 1994 and March 2026. The corpus accumulated 15,513 citations (average = 21.37 citations per paper; h-index = 59), and publication activity accelerated markedly after 2018, reaching 139 articles and 3,889 annual citations in 2025. China emerged as the leading contributor (171 publications, 23.55%), the ACM Journal on Computing and Cultural Heritage was the most productive outlet (39 publications), and Computer Science dominated the disciplinary

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landscape (260 publications). Within the analysed corpus, AR scholarship has accumulated the greatest citation impact to date, and the field displays a maturing, multidisciplinary structure. These findings offer an evidence base for tracing the evolution of immersive heritage research, identifying influential contributors and emerging directions, and informing collaboration, publication strategy, and technology adoption in cultural heritage and tourism management. To the authors' knowledge, this is the first PRISMA-guided bibliometric analysis of immersive and interactive technologies in this field based exclusively on the WoS Core Collection.

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Keyword:

Bibliometric Analysis, Cultural Heritage, Cultural Tourism, Immersive Technologies, Museums, Web of Science

Introduction

Cultural heritage institutions, including museums, historic sites, and cultural tourism destinations, have undergone significant transformation in recent decades as immersive and interactive technologies have entered their repertoire of tools for preservation, interpretation, and visitor engagement. Virtual reality (VR), augmented reality (AR), mixed reality (MR), virtual museums, virtual tours, and mobile heritage applications now feature across heritage-management practice, offering new ways for audiences to encounter tangible and intangible heritage (Bekele et al., 2018; Carrozzino & Bergamasco, 2010). In this context, immersion denotes the objective extent to which a display system can deliver an inclusive, extensive, surrounding, and vivid illusion of a virtual environment to a participant (Slater & Wilbur, 1997). The convergence of these technologies with cultural-heritage scholarship has generated a rapidly expanding body of research that spans technical implementation, user-experience evaluation, visitor-behaviour modelling, and heritage-conservation workflows (Suh & Prophet, 2018).

Although this body of work has grown rapidly, to the authors' knowledge it has not yet been synthesised through a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020-screened bibliometric analysis grounded specifically in the Web of Science (WoS) Core Collection. The present study addresses this gap by conducting a bibliometric performance analysis of 726 English-language articles and early-access records retrieved from the WoS Core Collection up to 31 March 2026.

Accordingly, this study pursues three objectives: i. To examine the productivity landscape of immersive and interactive technologies in cultural heritage, museums, and cultural tourism by identifying the ten most productive authors, institutions, countries or regions, and journals; ii. To assess the scholarly influence of the field by analysing annual citation trends and identifying

the ten most cited publications; iii. To map the multidisciplinary structure of the field by determining the distribution of publications across WoS research areas.

The data collected and the results obtained in this work are relevant for researchers, heritage practitioners, and research-policy actors at cultural-heritage institutions, since the study presents evidence on the most productive scholarly communities, the research areas with the highest production, the most influential authors for collaborations, the most cited documents, and the most productive publication venues. The findings thereby provide an evidence-based orientation for decisions about collaborative priorities, publication venues, postgraduate supervision, and future research directions in this rapidly maturing interdisciplinary domain.

Literature Review

Early research in this area concentrated on technical feasibility, including the development of virtual museum prototypes and evaluations of the capacity of virtual environments to reconstruct inaccessible or deteriorated heritage contexts (Carrozzino & Bergamasco, 2010; Sylaiou et al., 2010). From 2014 onwards, the literature broadened to encompass museum-learning outcomes (Chang et al., 2014), consumer-intention modelling in tourism (Chung et al., 2015), and theoretical frameworks for the acceptance of mobile AR at heritage sites (tom Dieck & Jung, 2018). A parallel line of inquiry has examined the role of AR in enhancing visitor experience and purchase intentions in museum settings (He et al., 2018), together with stakeholder-driven evaluations of AR value propositions at cultural-heritage sites (tom Dieck & Jung, 2017). More recently, the field has extended into immersive VR in real museum environments (Lee et al., 2020) and into consumer-behaviour and experience models in heritage tourism (Chung et al., 2018). Recent contributions have broadened this trajectory further, toward immersive documentation and metaverse-oriented information services for heritage figures (Fan et al., 2022) and emotional-design perspectives on extended reality for heritage preservation (Lin et al., 2025).

Measurement and comparison of research activity in a maturing field is essential for identifying scholarly influence, mapping thematic structure, and informing research-policy decisions. Bibliometric analysis provides a systematic quantitative approach to surveying the intellectual structure of a field, and recent methodological guidelines have codified best practice for both performance analysis and science mapping (Aria & Cuccurullo, 2017; Donthu et al., 2021). Prior bibliometric reviews in adjacent topics have illustrated the value of combining performance indicators with thematic mapping to highlight emerging research trajectories (Arcila-Diaz et al., 2025; Demir et al., 2025; Eftimov et al., 2025). A recent Scopus-based bibliometric study analysed 1,214 publications on virtual, augmented, and MR in cultural heritage between 2014 and June 2024 and reported substantial post-2018 growth, a concentration of high-impact work in tourism and human-computer interaction journals, and a multidisciplinary structure (Zhang et al., 2024).

However, to the authors' knowledge, the scholarship on immersive and interactive technologies in cultural heritage, museums, and cultural tourism has not, to date, been synthesised through a PRISMA 2020-compliant bibliometric analysis grounded specifically in the WoS Core Collection. Existing reviews have also tended to address narrower technological sub-domains, such as virtual museums alone, or single application contexts, such as tourism, rather than spanning VR, AR, MR, virtual and digital museums, virtual tours, and mobile heritage applications together.

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

Methodology

Database Selection and Search Strategy

A literature search of the WoS Core Collection was conducted on 31 March 2026 to obtain information on the scientific production of immersive and interactive technologies in cultural heritage, museums, and cultural tourism. The search covered the WoS Core Collection in its entirety, without restriction to a specific index or edition within it. The WoS Core Collection was selected because of its curated editorial policies, its broad coverage across science, technology, arts and humanities, and social sciences, and its established use in bibliometric research for reliable citation metadata and research-area tagging (Donthu et al., 2021; Mongeon & Paul-Hus, 2016).

The retrieval was restricted to records whose titles contained at least one immersive-technology term and at least one heritage-context term. The final search query combined two title-field (TI) conditions joined by AND, as follows:

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TI=("virtual tour*" OR "virtual visit*" OR "virtual heritage" OR "virtual museum*" OR "digital heritage" OR "digital museum*" OR "augmented reality" OR "virtual reality" OR "mixed reality" OR "mobile app*" OR "smartphone app*" OR "immersive technolog*") AND TI=("heritage" OR "museum*" OR "cultural heritage" OR "cultural tourism" OR "historic* site" OR "historical site*")
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After applying the search criteria, a total of 1,947 records were retrieved at the identification stage. A systematic verification process was conducted on each record to assess its eligibility against the inclusion criteria.

Selection Criteria and PRISMA 2020 Workflow

Record selection followed a four-stage screening workflow adapted from the PRISMA 2020 reporting guideline (Page et al., 2021; Passas, 2024), comprising identification, screening, eligibility assessment, and inclusion. The identification stage retrieved 1,947 records. In the pre-screening stage, 138 records were removed before screening: 11 retracted publications, 6 erratum records, 1 duplicate record, and 120 irrelevant records identified through manual inspection of titles, abstracts, and author keywords (Donthu et al., 2021).

The 120 irrelevant records excluded at the pre-screening stage comprised 35 records on digital preservation, archiving, and library management; 20 records on policy, governance, and political discourse surrounding digital heritage; 13 records on social media, blockchain, and online-community engagement without connection to immersive experiences; 10 records on purely technical digitisation, such as Light Detection and Ranging (LiDAR) scanning, point-cloud processing, and heritage building information modelling; 2 records on professional-training curricula unrelated to immersive-technology deployment; and 40 records on general digital-heritage theory, historiography, or commentary that did not investigate any form of immersive or interactive technology.

In the screening stage, 1,083 records were excluded because they fell outside the inclusion criteria, the document type not equal to Article or Early Access, or language not English. The remaining 726 English-language articles and early-access records were retained for inclusion

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

in the bibliometric analysis (Bozkul & Altun Uğraş, 2025; Demir et al., 2025; Effah, 2024). Figure 1 summarises the PRISMA-based bibliometric analysis workflow, covering objective definition, identification and merging, screening, inclusion, performance analysis outputs, data analysis and interpretation, and reporting.

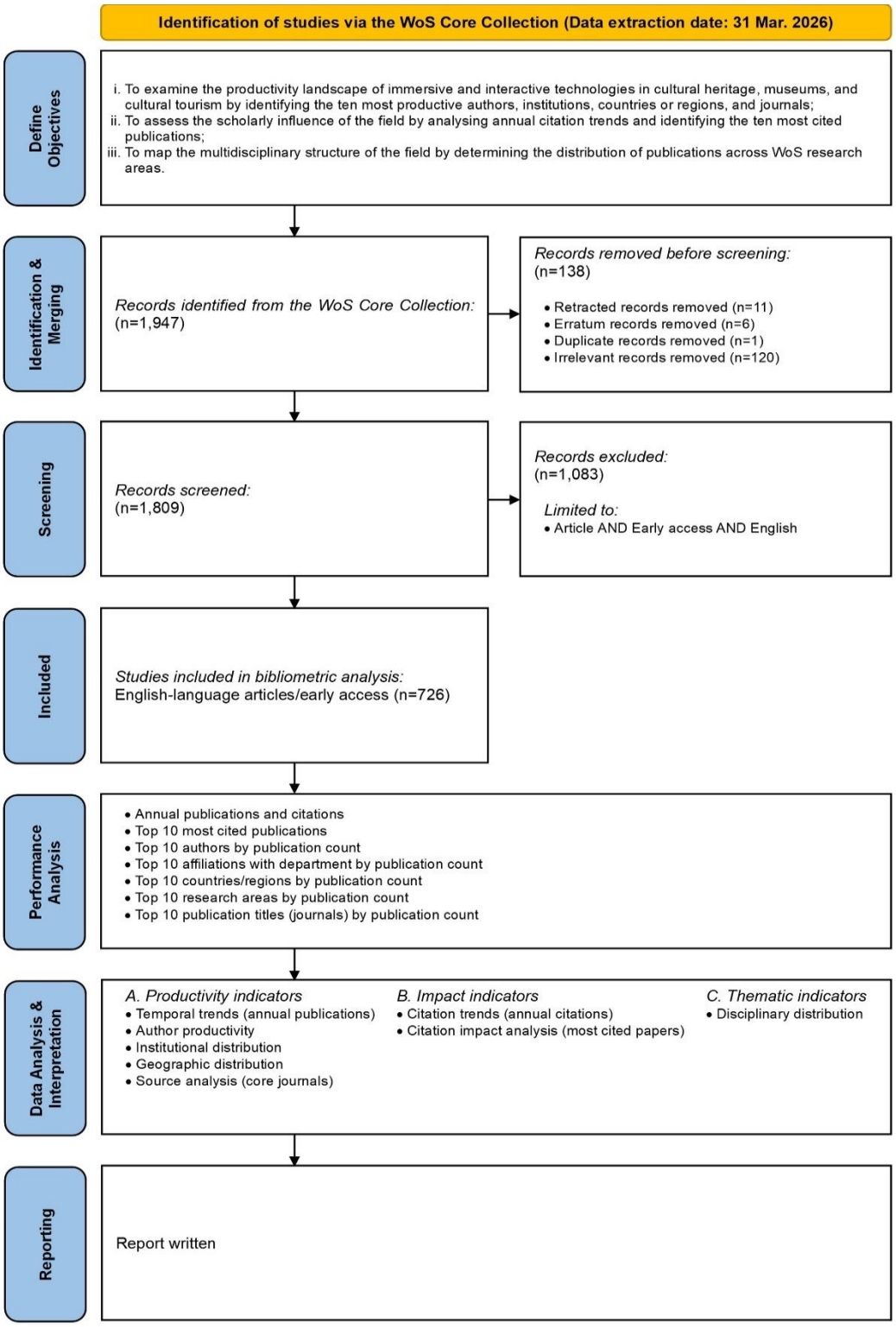

Figure 1: WoS PRISMA-Based Bibliometric Analysis Methodology

Source: Adapted from Page et al. (2021); Passas (2024)

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

Analytical Framework

The analytical framework comprised three families of indicators, drawing on the performance analysis component of the bibliometric methodology articulated by Donthu et al. (2021) and Aria and Cuccurullo (2017). The first family consists of productivity indicators, including temporal publication trends, author productivity, institutional distribution, geographic distribution, and source (journal) analysis. The second family consists of impact indicators, including temporal citation trends and the citation impact of the most cited publications. The third family consists of thematic indicators, based on the WoS research-area classification.

This framework operationalises the three research objectives of the study and produces the following outputs: annual publications and citations, the ten most cited publications, the ten authors with the highest publication counts, the ten affiliations with the department with the highest publication counts, the ten countries or regions with the highest publication counts, the ten research areas with the highest publication counts, and the ten publication titles (journals) with the highest publication counts.

Data Analysis Procedures

The 726 records retained for inclusion were exported from the WoS Core Collection together with their associated bibliographic metadata, including title, authors, source title, publication year, document type, digital object identifier (DOI), total citations, and annual citation counts from 1990 to 2026. For each of the author, affiliation, country, research-area, and publication-title top ten groups, individual record sets were retrieved from the WoS Analyze Results function and cross-checked against the master 726-record citation report to verify record counts, sum of the times cited (STC), average citations per item (AC/I), and h-index (Hirsch, 2005).

Microsoft Excel was used to organise the data by combining the parts of the downloaded citation reports and processing them to make the tables and graphs used to present the results. The Publication Year field was inspected for parsing errors, and one record with a malformed year field (a record whose title contained an embedded comma that shifted its source-title column during export) was recovered and correctly attributed to its publication year during counting. All aggregate descriptive statistics were computed directly from the exported citation-report files to maintain consistency between the aggregate table values and the underlying per-record data. The AC/I and h-index reported for each author, affiliation, country or region, journal, and research area are within-corpus indicators, derived from the times-cited values of the corpus records rather than from the entities' global citation records.

Because this study draws exclusively on secondary bibliographic metadata available in the WoS Core Collection, no human or animal subjects were involved and institutional ethics-board approval was not required.

Results

Annual Publication Trends

Scientific production on immersive and interactive technologies in cultural heritage, museums, and cultural tourism, indexed in the WoS Core Collection in the period 1994 to March 2026, is

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

reflected in the 726 documents retrieved. Figure 2 shows the annual scientific production of this corpus, with publication counts on the left axis and annual citation accumulation on the right axis.

Scholarly activity remained marginal during 1994 to 2004, beginning with 2 publications in 1994 and with no year exceeding four publications. A modest early-phase expansion occurred in 2005 (11 publications) and 2006 (13 publications), followed by a return to single-digit annual output during 2007 to 2014. From 2015 onwards, output rose steadily, from 11 publications (2015) to 23 (2016), 18 (2017), and 41 (2018), which indicates a first inflection from 2018 onwards. A second and much steeper inflection occurred from 2020 onwards, with annual output climbing from 50 publications (2020) to 57 (2021), 74 (2022), 73 (2023), 98 (2024), and a peak of 139 publications in 2025. The partial 2026 count (16 publications as of 31 March 2026) is consistent with continued high-volume activity. This trajectory suggests a growing attempt by the international scholarly community to publish research on immersive and interactive technologies in cultural heritage during the post-2018 period.

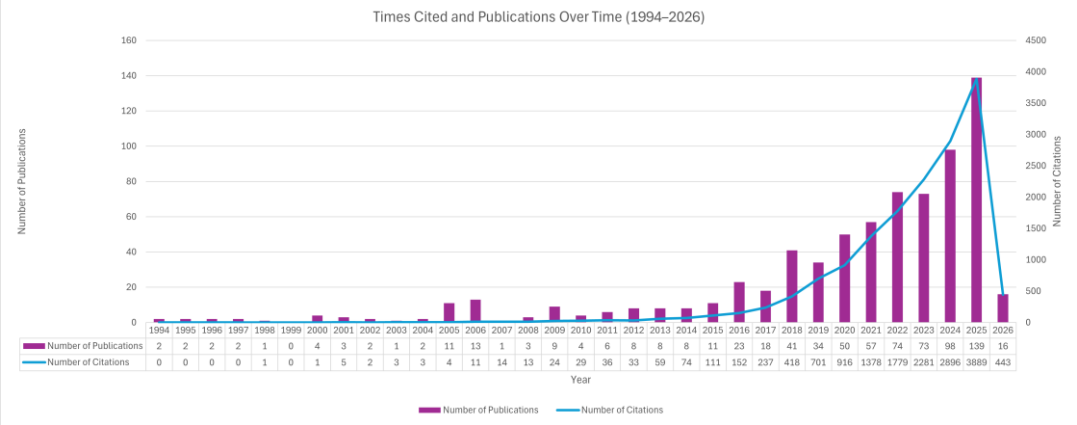

Figure 2: Annual Publications and Citations

Source: WoS

Top 10 Authors by Publication Count

Table 1 shows the ten most productive authors in the corpus, together with their publication-year start (PYS), number of publications (NP), STC, AC/I, and h-index. Author counts reflect the WoS author-disambiguation procedures, which consolidate orthographic variants of the same researcher and separate distinct researchers who share abbreviated name forms.

Table 1: Top 10 Authors by Publication Count in the Corpus

No.	Author	PYS	NP	STC	AC/I	h-index
1	tom Dieck MC	2016	**13**	1,781	137.00	12
2	Jung T	2016	**9**	827	91.89	8
3	Puritat K	2022	**9**	73	8.11	4
4	Intawong K	2024	**7**	45	6.43	4
5	Li Y	2012	**7**	61	8.71	4
6	Champion E	2011	**6**	162	27.00	5
7	Kim J	2017	**6**	189	31.50	6
8	Barrile V	2018	**5**	93	18.60	5
9	Chung N	2015	**5**	1,187	237.40	5

10	Fong LHN	2023	**5**	142	28.40	4

Note: tom Dieck MC is recorded in WoS as Dieck MCT; the corrected surname form is used here and throughout the manuscript. Source: WoS

Within the corpus, tom Dieck, M. C. ranked first in production (13 publications; STC = 1,781; AC/I = 137.00; h-index = 12), followed by Jung, T. (9 publications; STC = 827) and Puritat, K. (9 publications; STC = 73). The STC for the top three authors varies substantially, which suggests that publication volume and citation impact are not necessarily aligned. Chung, N. recorded the highest AC/I in the top ten (AC/I = 237.40), which may reflect the concentration of their five publications in highly cited works associated with the intellectual structure of consumer-behaviour research in heritage tourism (Chung et al., 2015, 2018). Puritat, K., Intawong, K., Barrile, V., and Fong, L. H. N. displayed more recent PYS (2018 or later), suggesting an emerging cohort of productive authors alongside more established contributors such as Champion, E. (PYS 2011) and Li, Y. (PYS 2012).

Top 10 Affiliations with the Department by Publication Count

Table 2 shows the ten most productive affiliations with the department in the corpus. Of the 726 records, 317 (43.66%) contained parseable affiliation-with-department metadata; the remaining 409 records (56.34%) did not contain data in this field and are therefore not reflected in the affiliation-with-department analysis.

Table 2: Top 10 Affiliations with the Department by Publication Count

No.	Affiliation with Department	PYS	NP	STC	AC/I	h-index
1	Jiangnan University, School of Design	2021	**9**	166	18.44	5
2	Manchester Metropolitan University, Faculty of Business and Law	2017	**9**	995	110.56	8
3	Chiang Mai University, Faculty of Public Health	2024	**7**	45	6.43	4
4	Kyunghee University, School of Management	2020	**7**	264	37.71	6
5	Chiang Mai University, College of Art, Media and Technology	2024	**6**	41	6.83	3
6	Curtin University, Faculty of Humanities	2015	**6**	751	125.17	6
7	Curtin University, School of Media, Creative Arts and Social Inquiry	2015	**6**	751	125.17	6
8	University of the Aegean, Department of Product and Systems Design Engineering	2009	**6**	132	22.00	6
9	University of the Aegean, School of Engineering	2009	**6**	132	22.00	6
10	Chiang Mai University, Department of Library and Information Science	2024	**5**	21	4.20	2

Note: Affiliation and department names are reported according to the WoS affiliation metadata and are retained as recorded. Source: WoS

The Jiangnan University School of Design and the Manchester Metropolitan University Faculty of Business and Law tied for the highest institutional output with 9 publications each, although their citation profiles differed substantially. The Manchester Metropolitan unit accumulated 995 citations (AC/I = 110.56; h-index = 8), coinciding with the research programmes of tom Dieck, M. C. and Jung, T. reported in Table 1, whereas the Jiangnan unit accumulated 166 citations (AC/I = 18.44; h-index = 5). Three institutions appear in the top ten

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

under multiple departments of the same institution: Chiang Mai University at ranks 3, 5, and 10 (Faculty of Public Health; College of Art, Media and Technology; Department of Library and Information Science), Curtin University at ranks 6 and 7, and the University of the Aegean at ranks 8 and 9. These department-level rows disaggregate a single institution by its WoS sub-organisations and may share the same underlying records, so the counts for the separate departments of one institution should not be summed. The three Chiang Mai University entries together contribute 18 publications concentrated from 2024 onwards, a pattern consistent with the emerging cluster of Thailand-based authors observed in Table 1.

Top 10 Countries or Regions by Publication Count

Table 3 presents the ten most productive countries or regions in the corpus. Country metadata was available for 720 of 726 records (99.17%); 6 records (0.83%) did not contain data in this field. Multi-country collaborative records are counted once per contributing country, so the sum of country-level publication counts can exceed the size of the corpus.

Table 3: Top 10 Countries or Regions by Publication Count

No.	Country or Region	PYS	NP	STC	AC/I	h-index
1	Peoples R China	2004	**171**	1,595	9.33	21
2	Italy	2004	**88**	3,159	35.90	28
3	England	2000	**74**	3,327	44.96	28
4	South Korea	2005	**57**	2,266	39.75	20
5	USA	1994	**56**	1,457	26.02	20
6	Spain	2009	**51**	926	18.16	18
7	Greece	2006	**36**	921	25.58	17
8	Australia	2008	**32**	1,204	37.63	13
9	Taiwan	2006	**26**	1,032	39.69	14
10	Turkiye	2023	**25**	145	5.80	6

Note: Country and region names are reported according to the WoS country and region metadata and are retained as recorded. Source: WoS

Peoples R China (or China) ranked first in production with 171 publications (23.55% of 726 records), nearly double the output of Italy (88 publications; 12.12%) and more than double England (74 publications; 10.19%). South Korea (57), USA (or the United States) (56), Spain (51), Greece (36), Australia (32), Taiwan (26), and Turkiye (or Türkiye) (25) completed the top ten. The top ten countries or regions jointly accounted for 616 country- or region-level publication attributions, equivalent to 84.85% of the corpus size. The impact profile of these countries varied considerably. Despite its leadership in volume, China recorded the lowest AC/I in the top ten among long-established contributors (9.33), whereas England (44.96), South Korea (39.75), Taiwan (39.69), Australia (37.63), and Italy (35.90) recorded substantially higher citation intensity per paper. This positioning is consistent with the maturing intellectual structure of the field in Europe and East Asia, where sustained contributions have had longer to accumulate citations. Turkiye entered the corpus most recently (PYS 2023) and recorded the lowest AC/I (5.80), consistent with the limited time available for citation accumulation.

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

Top 10 Publication Titles (Journals) by Publication Count

Table 4 presents the ten most productive publication titles (journals) in the corpus. A total of 323 distinct publication titles contributed to the 726-record corpus. The top ten publication titles together accounted for 198 publications, or 27.27% of the corpus.

Within the corpus, the ACM Journal on Computing and Cultural Heritage ranked first in production with 39 publications (STC = 1,460; AC/I = 37.44; h-index = 17), which is consistent with its explicit scope and its positioning as a dedicated specialist outlet within this corpus. Three Multidisciplinary Digital Publishing Institute (MDPI) journals, namely Applied Sciences-Basel (25 publications), Heritage (24), and Sustainability (21), together contributed 70 publications (9.64% of the corpus) and entered the top ten with PYS in 2018 to 2019, reflecting the recent expansion of the open-access multidisciplinary journal landscape. The Journal of Cultural Heritage recorded the highest AC/I in the top ten (66.27), followed by Current Issues in Tourism (54.00) and the ACM Journal on Computing and Cultural Heritage (37.44), which suggests that traditional peer-reviewed specialist venues continue to carry comparatively high citation weight in this field. Lecture Notes in Computer Science recorded the earliest PYS (1998) and the lowest AC/I (2.39), a pattern often seen in conference-proceedings series in the computing literature.

Table 4: Top 10 Publication Titles (Journals) by Publication Count

No.	Publication Title	PYS	NP	STC	AC/I	h-index
1	ACM Journal on Computing and Cultural Heritage	2014	39	1,460	37.44	17
2	Applied Sciences-Basel	2019	25	569	22.76	12
3	Heritage	2019	24	196	8.17	9
4	Sustainability	2018	21	507	24.14	13
5	International Journal of Human-Computer Interaction	2015	18	280	15.56	7
6	Lecture Notes in Computer Science	1998	18	43	2.39	4
7	Journal of Cultural Heritage	2010	15	994	66.27	13
8	Current Issues in Tourism	2018	14	756	54.00	8
9	Virtual Archaeology Review	2017	13	289	22.23	8
10	IEEE Access	2020	11	105	9.55	6

Source: WoS

Annual Citation Trend

Figure 2 shows the annual citation accumulation of the 726 publications in the corpus alongside the annual publication trend discussed above. The total number of citations consistently shows an increasing trend. Annual citations remained low until around 2009 and then rose steadily, climbing steeply from 2016 onwards (418 citations in 2018) to a peak of 3,889 in 2025, with the partial 2026 count (as of 31 March 2026) consistent with continued accumulation. The total sum of citations across the corpus is 15,513, with an average of 21.37 citations per paper and an h-index of 59.

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

The ratio between annual citations and annual publications in 2025, approximately 28 citations per publication in that year, suggests that the citation base of the field is maturing. Both the number of source publications available to cite and the community of authors citing them expanded within the same window. This pattern is visually evident in Figure 2, where the citation curve crosses the publication bars around 2018 and continues to grow at a steeper rate thereafter. This is consistent with the rapid growth phase identified in the productivity analysis and with a field moving from an exploratory toward a consolidation phase.

Top 10 Most Cited Publications

Table 5 shows the ten most cited publications in the corpus, together with their first author, publication title, year, and total citations (TC). The data offer useful resources for analysing citation patterns and for identifying foundational works in the intellectual structure of the field.

Bekele et al. (2018) ranked first with 637 citations in the ACM Journal on Computing and Cultural Heritage, a survey article whose citation lead may reflect the common pattern whereby comprehensive reviews tend to accumulate comparatively high citations once a field reaches a take-off phase. Four of the top ten publications (ranks 1, 4, 6, and 7 in Table 5) appeared in 2018, corresponding to the first inflection point visible in Figure 2. Five further publications were published before 2018, covering the foundational period of the field (ranks 2, 3, 8, 9, and 10), and one publication (rank 5) appeared in 2020. Seven of the ten most cited publications are centred on AR or mobile AR (ranks 1, 2, 4, 6, 7, 8, and 10 in Table 5), while three are centred on VR or virtual museums (ranks 3, 5, and 9), which suggests that, within this corpus, AR scholarship has to date accumulated greater citation impact than VR scholarship in the cultural-heritage, museum, and cultural-tourism context. The ten publications appeared in ten different journals, which is consistent with the multidisciplinary structure of the corpus observed in Table 4.

Table 5: Top 10 Most Cited Publications in the Corpus

No.	Title	Source	Publication Title	Year	TC
1	A survey of augmented, virtual, and mixed reality for cultural heritage	Bekele et al. (2018)	ACM Journal on Computing and Cultural Heritage	2018	**637**
2	Tourists' intention to visit a destination: The role of augmented reality (AR) application for a heritage site	Chung et al. (2015)	Computers in Human Behavior	2015	**400**
3	Beyond virtual museums: Experiencing immersive virtual reality in real museums	Carrozzino and Bergamasco (2010)	Journal of Cultural Heritage	2010	**383**
4	A theoretical model of mobile augmented reality acceptance in urban heritage tourism	tom Dieck and Jung (2018)	Current Issues in Tourism	2018	**305**
5	Experiencing immersive virtual reality in museums	Lee et al. (2020)	Information & Management	2020	**301**
6	When art meets tech: The role of augmented reality in enhancing	He et al. (2018)	Tourism Management	2018	**288**

	museum experiences and purchase intentions				
7	The role of augmented reality for experience-influenced environments: The case of cultural heritage tourism in Korea	Chung et al. (2018)	Journal of Travel Research	2018	**282**
8	Development and behavioral pattern analysis of a mobile guide system with augmented reality for painting appreciation instruction in an art museum	Chang et al. (2014)	Computers & Education	2014	**251**
9	Exploring the relationship between presence and enjoyment in a virtual museum	Sylaiou et al. (2010)	International Journal of Human-Computer Studies	2010	**219**
10	Value of augmented reality at cultural heritage sites: A stakeholder approach	tom Dieck and Jung (2017)	Journal of Destination Marketing & Management	2017	**213**

Source: WoS

Top 10 Research Areas by Publication Count

Table 6 presents the ten most productive WoS research areas in the corpus. Because records in the WoS Core Collection are frequently tagged under more than one research area, the sum of research-area-level publication counts can exceed the size of the corpus. The corpus spans 53 distinct research areas in total, and the top ten account for 880 research-area assignments.

Computer Science ranked first in production with 260 publications (35.81% of 726 records) and recorded the highest h-index in the top ten (h-index = 37), consistent with the computationally oriented foundations of the field. Arts and Humanities, Other Topics (116 publications) and Engineering (116 publications) tied at the second rank, each contributing 15.98% of the corpus. Social Sciences, Other Topics ranked fourth by volume (88 publications) but recorded the highest AC/I in the top ten (43.50) and the second-highest h-index (29), which may reflect the concentration of highly cited tourism- and consumer-behaviour publications within this area (ranks 2, 5, and 7 are all categorised under this area; see Table 5).

Archaeology (38 publications), Chemistry (56 publications), and Materials Science (51 publications) represent heritage-conservation-oriented subfields with consistently high AC/I values (37.47, 33.23, and 32.29 respectively), which suggests sustained citation impact in domain-specific applications. Three research areas in the top ten carry the Other Topics suffix (Arts and Humanities, Social Sciences, and Science and Technology) and together contribute 270 research-area assignments (equivalent to 37.19% of the corpus size) to explicitly interdisciplinary categories. This finding is consistent with the multidisciplinary structure of scientific production identified in the authorship, institutional, and journal analyses reported in the productivity analysis (Table 1 to Table 4).

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

Table 6: Top 10 Research Areas by Publication Count

No.	Research Area	PYS	NP	STC	AC/I	H-index
1	Computer Science	1995	**260**	5,476	21.06	37
2	Arts and Humanities, Other Topics	2008	**116**	2,151	18.54	22
3	Engineering	1996	**116**	2,326	20.05	28
4	Social Sciences, Other Topics	2008	**88**	3,828	43.50	29
5	Science and Technology, Other Topics	2011	**66**	845	12.80	18
6	Chemistry	2010	**56**	1,861	33.23	23
7	Education and Educational Research	2008	**54**	1,266	23.44	16
8	Materials Science	2010	**51**	1,647	32.29	20
9	Archaeology	2010	**38**	1,424	37.47	17
10	Art	1994	**35**	1,139	32.54	15

Source: WoS

Discussion

The findings of this analysis contribute to the understanding of how immersive and interactive technologies have been taken up in cultural heritage, museums, and cultural tourism scholarship, and they extend the recent Scopus-based bibliometric analysis of virtual, augmented, and MR in cultural heritage reported by Zhang et al. (2024) in two respects: by drawing on the WoS Core Collection rather than Scopus, and by applying a PRISMA 2020 workflow (Page et al., 2021) that explicitly documents every record removed at each stage. The overall shape of the trajectory reported in this study (a take-off from 2018 onwards and rapid growth through 2025) corroborates the pattern observed by Zhang et al. (2024) and extends it by two further years of data. This convergence across databases and workflows lends further support to a post-2018 inflection across the two databases considered.

The 2018 inflection in annual output coincides with the appearance of four highly cited theoretical and empirical contributions in that single year (Bekele et al., 2018; Chung et al., 2018; He et al., 2018; tom Dieck & Jung, 2018), a concentration that may not be coincidental. These four papers coincided with a shift in scholarly attention from technical implementation toward user-experience modelling, consumer-intention theorising, and value-framework construction in heritage tourism. The subsequent rapid growth in annual output suggests that theoretical consolidation (the availability of a coherent set of frameworks on which empirical work can be built) may have facilitated broader scholarly uptake. This interpretation is consistent with bibliometric-methodology observations that comprehensive reviews and theory-building pieces tend to accumulate comparatively high citation weight once a field reaches a take-off phase (Donthu et al., 2021).

The divergence between publication volume and citation intensity in the national production profile (Table 3) is worth unpacking. China led the corpus by publication volume but recorded the lowest AC/I in the top ten, whereas England, South Korea, Italy, Taiwan, and Australia recorded markedly higher citation intensity on smaller output bases. Several factors may contribute to this volume-to-impact divergence. The Chinese corpus has grown substantially only since 2019, so its time-to-citation is shorter. Much of the Chinese output appears in domain-specialist and open-access venues that, while important for rapid dissemination, accumulate citations more slowly than the flagship specialist venues that host the most cited works (Table 4). Finally, English-language reach and reviewer-community familiarity may

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

favour contributions from the established Anglophone and European clusters. The volume-to-impact divergence may therefore reflect a combination of temporal, venue-level, and network-level effects, none of which should be read as a judgement on research quality.

The seven-to-three ratio between AR and VR papers in the ten most cited publications (Table 5) is a notable finding and merits cautious interpretation. It is consistent with the observation that AR, which overlays contextual information on real heritage environments without removing the visitor from the physical setting (Azuma, 1997), may be more readily adoptable in museum and heritage-site operations than head-mounted VR, which requires dedicated hardware and supervised spaces. The citation dominance of AR papers also coincides with their stronger grounding in mature behavioural-science frameworks such as technology acceptance (Davis, 1989) and related behavioural models, which have provided a well-understood scaffold for empirical testing and replication (Chung et al., 2015, 2018; He et al., 2018; tom Dieck & Jung, 2018). VR scholarship in heritage contexts, by contrast, has tended to privilege prototype design, presence measurement, and immersive experience description (Lee et al., 2020; Sylaiou et al., 2010), which are valuable but accumulate citations at a different pace.

The disciplinary distribution (Table 6) is consistent with a multidisciplinary structure of the field. Computer Science, Arts and Humanities Other Topics, Engineering, and Social Sciences Other Topics together account for 580 of the 880 top-ten research-area assignments. Three research areas carry the Other Topics suffix and together contribute 270 research-area assignments, equivalent to 37.19% of the corpus size, to explicitly interdisciplinary categories. This is consistent with the theoretical framing of immersive-technology research in heritage contexts as a convergent rather than a single-discipline endeavour, and it aligns with arguments in recent bibliometric-methodology work that fields sustained by cross-disciplinary pollination require both performance analysis and science mapping to be characterised fully (Aria & Cuccurullo, 2017; Donthu et al., 2021). The high AC/I values recorded in the heritage-conservation-oriented subfields of Archaeology (37.47), Chemistry (33.23), and Materials Science (32.29) also indicate that domain-specific applications (for example, virtual reconstruction of decayed surfaces, spectral documentation of pigments, and immersive conservation-training workflows) continue to attract sustained citation impact despite representing a smaller slice of the overall output.

The institutional-affiliation results (Table 2) reveal three partly overlapping structural features. First, productivity is concentrated in a small number of institutional units, with Chiang Mai University, Curtin University, and the University of the Aegean each appearing in the top ten under multiple departments of the same institution (three departments for Chiang Mai University; two each for Curtin University and the University of the Aegean), and the remainder of the top ten distributed across three further institutions. Second, the Manchester Metropolitan University Faculty of Business and Law cluster coincides with the research programmes of tom Dieck, M. C. and Jung, T. (Table 1), indicating that author-level productivity and institutional productivity in this corpus track one another closely. Third, the Chiang Mai University cluster, with a combined output of 18 publications concentrated from 2024 onwards, signals an emerging South-East Asian node whose trajectory warrants continued monitoring.

Taken together, the findings are consistent with the field being at a consolidation stage, in which a dedicated specialist journal (ACM Journal on Computing and Cultural Heritage, Table 4) accompanies a maturing scholarly community, a small set of theoretically oriented 2018 papers

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65
accounts for much of the citation structure, and a cohort of emerging authors and institutions is entering the field from Thailand, China, and elsewhere. The evidence supports both theoretical and practical inferences that are taken up in the implications subsections below.

Theoretical Implications

The findings of this analysis carry several theoretical implications for research on immersive and interactive technologies in cultural heritage, museums, and cultural tourism. The 2018 inflection in annual output (Figure 2) and the subsequent growth through 2025, together with the multidisciplinary research-area distribution (Table 6), are consistent with a field moving from an exploratory toward a consolidation phase whose intellectual structure spans several disciplines. The concentration of four top-cited publications in 2018 (Table 5), alongside the emergence in that year of tourism- and consumer-behaviour-oriented theoretical contributions (Chung et al., 2018; He et al., 2018; tom Dieck & Jung, 2018), suggests that theoretical progress in the field has tracked the broadening of research from technical implementation toward user-experience modelling. This shift situates the field at a conceptual intersection between human-computer interaction, consumer behaviour, and heritage-interpretation theory, and it may point toward opportunities for cross-disciplinary theoretical integration in subsequent work.

Practical Implications

For heritage practitioners, research-policy actors, and postgraduate researchers, the findings carry practical implications in three areas. First, the identification of productive authors, institutions, countries or regions, and journals (Table 1 to Table 4) supports more informed decisions about collaborative partnerships, doctoral supervision, and target publication venues. Four institutions offer potential points of contact for new research collaborations: the Manchester Metropolitan University Faculty of Business and Law cluster (Table 2), the Kyunghee University School of Management, Curtin University, and the University of the Aegean, with the last two each represented in the top ten under two different departments of the same institution. Chiang Mai University, represented in the top ten under three different departments of the same institution, may constitute an emerging node for South-East Asian partnerships. Second, the journal landscape (Table 4) shows a pronounced divergence between high-impact specialist venues (the Journal of Cultural Heritage, Current Issues in Tourism, and the ACM Journal on Computing and Cultural Heritage) and high-volume open-access venues (Applied Sciences-Basel, Heritage, and Sustainability). Authors selecting publication venues may wish to weigh these trade-offs (citation intensity versus speed and openness of dissemination) alongside their research goals and disciplinary positioning. Third, the identification of the ten most cited publications (Table 5) provides an orientation corpus for newcomers to the field, particularly for courses and reading lists in museum studies, tourism management, cultural-heritage informatics, and human-computer interaction.

Proposed Research Agenda

Table 7 presents a forward-looking research agenda derived from the bibliometric findings. Each focus area draws on an empirical pattern observed in the Results and is paired with a possible research question to guide further investigation.

Journal of Tourism, Hospitality and Environment Management
JTHEM
EISSN: 0128-178X
Volume 11 Issue 45 (September 2026) PP. 44-65

Table 7: Proposed Research Agenda

Focus Area	Justification Grounded in Findings	Possible Research Question
Emerging South-East Asian cluster	Chiang Mai University appeared in the top ten affiliations (Table 2) under three different departments of the same institution, all with PYS in 2024; Puritat, K. (PYS 2022) and Intawong, K. (PYS 2024) appeared in the top ten authors (Table 1).	How are national research-policy instruments in South-East Asia shaping the rapid emergence of the Chiang Mai research cluster, and what collaborative networks have enabled its growth?
Volume-impact divergence in the Chinese contribution	China ranked first in production with 171 publications (23.55%) but recorded a comparatively modest AC/I of 9.33 (Table 3).	What factors explain the divergence between publication volume and citation intensity in the Chinese contribution to this field, and how might this divergence evolve over time?
AR versus VR impact	Seven of the ten most cited publications are centred on AR, while three are centred on VR or virtual museums (Table 5).	What accounts for the differential citation performance of AR and VR in cultural-heritage, museum, and cultural-tourism research, and how does this performance vary across visitor-experience and heritage-conservation applications?
Multidisciplinary bridging	Three Other Topics research areas together accounted for 270 research-area assignments, equivalent to 37.19% of the corpus size (Table 6); the top three research areas span Computer Science, Arts and Humanities, and Engineering.	How can interdisciplinary research designs more systematically bridge the Computer Science, Social Sciences, and Arts and Humanities research areas that currently host the majority of publications?
Post-2018 inflection point	Annual publications rose from 41 (2018) to 139 (2025), and annual citations rose from 418 (2018) to 3,889 (2025) (Figure 2).	What research-infrastructure, funding, and technological developments from 2018 onwards produced the inflection in both output and citation intensity, and which are likely to persist?
Conservation-science integration	Chemistry, Materials Science, and Archaeology each appeared in the top ten research areas with AC/I values above 32 (Table 6).	How can immersive and interactive technologies be more systematically integrated with heritage-conservation science in ways that jointly advance visitor experience and scientific documentation?

Affiliation-with-department metadata coverage	Affiliation-with-department metadata was available for only 43.66% of records (Table 2).	How might bibliometric and repository infrastructures improve department-level affiliation coverage for cultural-heritage research, so that institutional analyses rest on more complete metadata?

Source: Research agenda derived from the findings reported in the Results section

Limitations

The primary limitation of this research is that scientific production was evaluated only through the WoS Core Collection, so publications indexed exclusively in alternative databases (such as Scopus, Dimensions, or SciELO) were not captured, which may under-represent regional and non-English-language scholarship, reflecting the known coverage and language biases of the WoS and Scopus (Mongeon & Paul-Hus, 2016). A related limitation is that inclusion was restricted to English-language articles and early-access records, which excludes a substantive body of work published in Italian, Spanish, Chinese, Korean, French, and other languages. Because retrieval was confined to the title field to maximise precision, relevant publications that address these technologies without using the search terms in their titles may not have been captured, so the corpus should be read as a high precision rather than exhaustive sample of the field.

The citation profile of the corpus also shows strong dependence on individual high-impact works (for example, Bekele et al. (2018) alone contributes 637 of 1,460 citations to the ACM Journal on Computing and Cultural Heritage), so some journal- and country-level citation statistics are sensitive to single-paper effects, a known feature of citation-based indicators (Donthu et al., 2021). Because WoS citation counts are dynamic, all citation-based indicators reported here reflect the state of the database at the extraction date of 31 March 2026 and would differ at a later retrieval. The present study is further confined to a performance analysis, with the science-mapping component (co-authorship networks, bibliographic coupling, and keyword co-occurrence) identified as an important extension for subsequent work (Aria & Cuccurullo, 2017; Cobo et al., 2011; Moral-Muñoz et al., 2020; van Eck & Waltman, 2010; Zupic & Čater, 2015). Notwithstanding these constraints, the main strengths of this study are that the WoS Core Collection is one of the most curated bibliographic databases, that the selection workflow follows the PRISMA 2020 guideline (Page et al., 2021), and that all descriptive statistics were cross-checked against the master 726-record citation report. Complementing these findings with research drawing on other indexed databases, such as Scopus and Dimensions, whose journal coverage differs substantially (Singh et al., 2021), and extending the analysis with science-mapping techniques, would provide a fuller picture of the total scholarly impact of immersive and interactive technologies in cultural heritage, museums, and cultural tourism.

Conclusion

This study contributes an evidence-based mapping of the scholarly landscape of immersive and interactive technologies in cultural heritage, museums, and cultural tourism, based on a PRISMA 2020-screened bibliometric performance analysis of 726 English-language articles and early-access records retrieved from the WoS Core Collection up to 31 March 2026. The

analysis documented a marked growth trajectory, with annual output rising from 2 publications (1994) to 139 (2025), and total citations reaching 15,513 (average citations per paper = 21.37; h-index = 59). Within the analysed corpus, tom Dieck, M. C. and Jung, T. led by productivity, whereas Chung, N. recorded the highest citation intensity among the leading authors; the Manchester Metropolitan University Faculty of Business and Law was the leading affiliation by citation impact; China was the leading contributor by publication volume; the ACM Journal on Computing and Cultural Heritage was a leading specialist outlet within the corpus; and Computer Science was the leading research area by publication count.

Likewise, in terms of research trends, the ten most cited publications span AR, VR, and virtual museum research in a ratio of approximately seven to three, which points to a field in which AR scholarship appears to have accumulated greater citation impact within this corpus to date. The thematic distribution across ten WoS research areas, with 37.19% of the corpus tagged under explicitly interdisciplinary Other Topics categories, is consistent with a multidisciplinary structure of the field. A forward-looking research agenda (Table 7) translates these findings into seven focus areas for further investigation, covering the emerging South-East Asian cluster, the volume-impact divergence in Chinese output, augmented-versus-virtual-reality impact, multidisciplinary bridging, the post-2018 inflection, conservation-science integration, and affiliation-metadata coverage.

The scholarly literature on immersive and interactive technologies in cultural heritage, museums, and cultural tourism, characterised by the preponderance of Computer Science, Arts and Humanities, and Engineering research areas, spans user-experience modelling and heritage-conservation science, which suggests potential for closer integration of the two. Subject to the limitations outlined above, the findings offer an evidence-based orientation for researchers, heritage practitioners, and research-policy actors engaging with this rapidly maturing interdisciplinary literature. The principal contribution of this study is a PRISMA 2020-screened, WoS-based bibliometric performance analysis that spans VR, AR, MR, virtual and digital museums, virtual tours, and mobile heritage applications together, which, to the authors' knowledge, prior reviews with a narrower scope have not provided. Subsequent work should extend the present performance analysis through science-mapping analyses (co-authorship networks, bibliographic coupling, and keyword co-occurrence) and through multi-database triangulation across the WoS, Scopus, and Dimensions.

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Journal of Tourism, Hospitality and Environment Management
JTHEM
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