Virtual Reality and Augmented Reality Applications and their Effect on Tourist Engagement: A Hybrid Review

ABSTRACT

Purpose – This study consolidates insights on the role of Virtual Reality (VR) and Augmented Reality (AR) in Tourism Engagement (TE). Additionally, it suggests new directions for research tourism and hospitality.

Design/Methodology/Approach – A hybrid integrative review was employed with bibliometric and Theory-Context-Characteristics-Method (TCCM) framework analyses of 236 peer-reviewed journal articles.

Findings – Computer science journals dominate TE in VR/AR research. Emotional and immersive attributes of VR/AR sustain TE. Exploring cultural theories can enrich TE perspectives in the context of VR/AR. This study offers fruitful directions by exploring virtual technology's role in sustaining cultural heritage, and studying TE intentions and perceptions on VR/AR tourism mobile applications.

Originality – This is the first study that uncovers the structure and intellectual rationale of existent research.

Keywords: Tourist Engagement, Virtual Reality, Augmented Reality, Hybrid Review.
Paper Type: Literature Review.

INTRODUCTION

Researchers have been studying Virtual Reality (VR) and Augmented Reality (AR) for a long time (Loureiro, *et al.*, 2020; Yung and Khoo-Lattimore, 2019). As digital technologies evolve, users reshape their experiences (Wei, 2019), and organizations have been exploiting this interaction to sustain competitive advantage (Rasoolimanesh *et al.*, 2019). VR creates a 3D-simulated environment, evoking real-world sensations, enabling engagement with virtual spaces and overcoming intangible limitations (Gupta *et al.*, 2020). AR uses computer-generated images to enhance the physical world and facilitates real-world interactions (Nejad *et al.*, 2021).

These technologies, increasingly prevalent in tourism, not only enable tourists to foretaste attractions and destinations, but also aid them in their travel decisions, and are emerging turning points in tourism and hospitality, offering a personalized and interactive environment (Nayyar et al., 2018). Tourists can overview their journey, connect with providers, and share prior experiences, which holds potential for value co-creation in tourism and hospitality (Yung and Khoo-Lattimore, 2019; Moro *et al.*, 2019). For instance, *Google Earth VR* enables virtual 3D tours around the globe, enriching visitor experience and co-creation (Gupta *et al.*, 2020).

VR and AR enhance TE's cognitive, emotional, and behavioral dimensions through interactivity, immersion, and imageries, leading to memorable experiences (Verma, 2022). TE is a cognitive state arising from interactions between tourists, attractions and encounters (Brodie *et al.*, 2011), representing the emotional bond and social interactions, and deepening attachment between tourists and destinations (Chen and Rahman, 2018; Wei, 2019). TE through VR/AR fosters lasting bonds between tourists and destinations, thus boosting visit intentions and loyalty (Kusumah *et al.*, 2022). This growing interest in VR/AR in the tourism sector has led to more publications and fragmented research

streams (Guo *et al.*, 2021; Hulland and Houston, 2020). Given the rising number of publications and the strategic role of VR/AR in enhancing tourist interaction (Verma *et al.*, 2022), a systematic review of TE through VR/AR is crucial. Systematic reviews consolidate knowledge, highlight gaps, and guide future research (Palmatier *et al*., 2018). Recent systematic literature reviews have investigated the role of VR/AR in tourism. Yung and Khoo-Lattimore (2019) systematically reviewed 46 manuscripts on the role of VR/AR in tourism, focusing on their evolution, contexts, and methodologies, emphasizing the focus on marketing and tourism education, but indicating a lack of theory-based research. Wei (2019) assessed 60 papers on the developments of VR/AR in hospitality and tourism. Their review stressed that these technologies impact tourist, and summarized research features such as stimuli and user behavior dimensions. Liang and Elliott (2021) conducted a bibliometric meta-analysis of 32 articles to examine the status of AR research in tourism. The authors identified five research clusters, primarily focusing on user acceptance of AR, and integrated past findings into a unified model.

The abovementioned reviews identified gaps and inconsistencies, and suggested future research directions. Nonetheless, consolidating fragmented VR/AR research from a TE viewpoint remains unaddressed. No research has yet mapped the evolution of this field by identifying key authors, articles, journals, and network analyses in VR/AR from a TE standpoint. This topic lacks an understanding of common theories, concepts, and research methods. Thus, it is vital to thoroughly examine the role of VR/AR in driving TE between tourists and destinations.

This study used a hybrid review, integrating bibliometric and Theory-Context-Characteristics-Method (TCCM) framework analyses. The bibliometric analysis evaluates relationships within emerging research topics (Donthu et al., 2021), and given the primarily descriptive nature of bibliometric analysis (Palmatier et al., 2018), TCCM

analysis was added to address the theory-based research gap identified in previous reviews (Singh and Dhir, 2019).

There are differences between a bibliometric analysis, a framework-based review, and a theory-based review. A bibliometric analysis, a citation-based review, provides insights into research domains (Paul and Bhukya, 2021). Both framework- and theory-based reviews synthesize literature by using similar frameworks and theories (Chen *et al.*, 2021). Systematic reviews are qualitative, while meta-analysis and bibliometric analysis are quantitative (Paul and Bhukya, 2021). A bibliometric analysis was chosen over a systematic review both for its insight into TE via VR/AR and its ability to identify and address inconsistencies. Furthermore, it consolidates current knowledge and outlines future research (Hulland, 2020). TCCM complements the bibliometric analysis by identifying gaps and suggesting future research directions (Paul and Criado, 2020).

This hybrid review (1) offers a comprehensive picture of TE via VR/AR, enabling an overview of current knowledge in the topic (Hulland and Houston, 2020); (2) addresses inconsistencies in the research domain (Hulland, 2020); and (3) points to future research avenues (Palmatier *et al.*, 2018) by helping researchers pinpoint issues for future exploration (Paul and Bhukya, 2021).

Based on this mixed approach, this study addresses the following research questions:

Research Question 1 (RQ1): How has the research trajectory of Virtual Reality/Augmented Reality technologies in promoting Tourist Engagement evolved?

Research Question 2 (RQ2): What is the knowledge framework for Virtual Reality/Augmented Reality in Tourist Engagement?

Research Question 3 (RQ3): What are the Theory-Context-Characteristics-Methods of the existing research?

Research Question 4 (RQ4): What future research paths can further Virtual Reality/Augmented Reality in Tourist Engagement?

This study seeks to bring valuable insights for the scientific literature by providing a comprehensive literature review, identifying gaps, and suggesting future research avenues for TE via the VR/AR research field. The aggregated knowledge can aid researchers in acknowledging the field's state-of-the art and shed additional light on such a dynamic and vibrant topic.

This paper is organized with a section containing the design of the mixed-methods approach using bibliometric analysis and TCCM. This is followed by the results, discussion, and implication of the findings for TE researchers and tourism marketers. The final section presents the conclusion and highlights potential future research avenues.

METHODOLOGY

Selection Strategy

First, a bibliometric analysis was performed, concentrating on the intertwined role of VR/AR in TE. A bibliometric analysis encompasses performance and science mapping (Rita and Ramos, 2023). A performance analysis evaluates articles, authors, and journals based on the number of citations and publications. Science mapping uses authors' keywords to visually depict co-occurrence analysis, spotlighting the latest scholarly insights in a specific domain (Donthu *et al.*, 2021). We gathered keywords from prior reviews relevant to our study (Hao, 2020; Liang and Elliot, 2021; Loureiro *et al.*, 2020; Moro *et al.*, 2019; So *et al.*, 2020; Wei, 2019; Yung and Khoo-Lattimore, 2019) to create a search query (see Annex I).

The final dataset comprised 236 documents, following the classification defined by Scopus: 97 articles, 20 book chapters, 111 conference papers, and eight reviews. We

included more sources in the bibliometric analysis than in the TCCM to bolster the validity of the findings (Donthu *et al.*, 2021). A bibliometric analysis gains strength and validity the greater the number of reviewed papers, thus boosting the findings' credibility and impact (Belter, 2015).

The TCCM relied on 97 articles deemed adequate to probe the research gap in TE via VR/AR. The articles were selected for their most current and advanced knowledge sources (Rita and Ramos, 2023). This method was conducted by reviewing each article to identify prevailing TCCMs from existing research.

Each article was reviewed to extract TCCMs (Rauscher, 2021). The theories were identified by analyzing papers to determine the prevailing theoretical models for TE queries. Similarly, the 'context' was identified by searching the papers for the most prevalent settings (i.e., hotels, theme parks, and cultural heritage sites) where TE research has been conducted. The study's 'characteristics' were identified by reading the papers and highlighting study themes used. The 'methods' were extracted by reading the papers to identify dominant research methodologies.

Data Collection and Analysis

We collected the authors' names, articles' titles, source titles, publication years, and keywords. The CSV file provided the input for the R-tool mapping analysis, particularly the "bibliometrix" package. This package supports various bibliometric analyses, including citation, authors' productivity metrics, and co-occurrence analyses (Aria and Cuccurullo, 2017). Authors' metrics gauge the researcher's work, helping to identify key researchers in the field. The *h*-index, *g*-index, and *m*-index were used to calculate these metrics. The *h-index* is the most common metric based on the number of citations and publications (Hirsch, 2005). The *g*-index enhances the *h*-index by assessing an article's

overall citation impact (Egghe, 2006). The *m*-index, derived from the *m*-value, indicates an author's success and aids in comparing authors (Halbach, 2011).

RESULTS AND DISCUSSION

This section presents the findings of the bibliometric and TCCM analyses. The results highlight existing knowledge structures, gaps, and potential avenues for future research.

Bibliometric Analysis

In addressing RQ1, the bibliometric analysis, built on 236 documents (see Annex II), offers key insights. The growing publication rate over time reflects the escalating interest in the subject, which can be attributed to several factors: the widespread adoption of mobile devices (smartphones and tablets) (Verma *et al.*, 2022); movement restrictions due to COVID-19 and the rise of virtual technologies (Meng *et al.*, 2022); the prominence of the tourism sector, coupled with evidence of these technologies enhancing TE (Verma *et al.*, 2022), and availability of data on this topic (Jiang *et al.*, 2022).

Annex III highlights the leading sources on VR/AR-based TE research. Annexes IV and V list the Top 10 most productive and impactful authors, highlighting the prominence of computer science experts in this domain. Computer science journals are intrinsically linked to TE publications involving VR/AR, as these technologies leverage computer systems to craft immersive experiences (Leung *et al.*, 2022). Surprisingly, these sources have yet to consistently delve into the tourism and hospitality research fields. Several factors may explain this: TE via VR/AR technologies remains relatively novel in tourism and hospitality;, therefore their potential benefits in these sectors are not fully acknowledged (Verma *et al.*, 2022), and their gradual adoption in tourism and hospitality may explain the limited research interest.

Analysis of Keyword Co-Occurrence

In addressing RQ2, we analyzed keyword co-occurrence to delineate TE's VR and AR research domains (Khalifah *et al.*, 2022) (Figure 1). The authors cited 653 keywords that support the bibliometric analysis. The nodes represent keywords or topics, with size reflecting frequency, and links between nodes denote co-occurrences, with thickness indicating their strength (Donthu *et al.*, 2021). Six primary clusters emerged: "VR," "AR," "cultural heritage," "mixed reality," "engagement," and "museum."

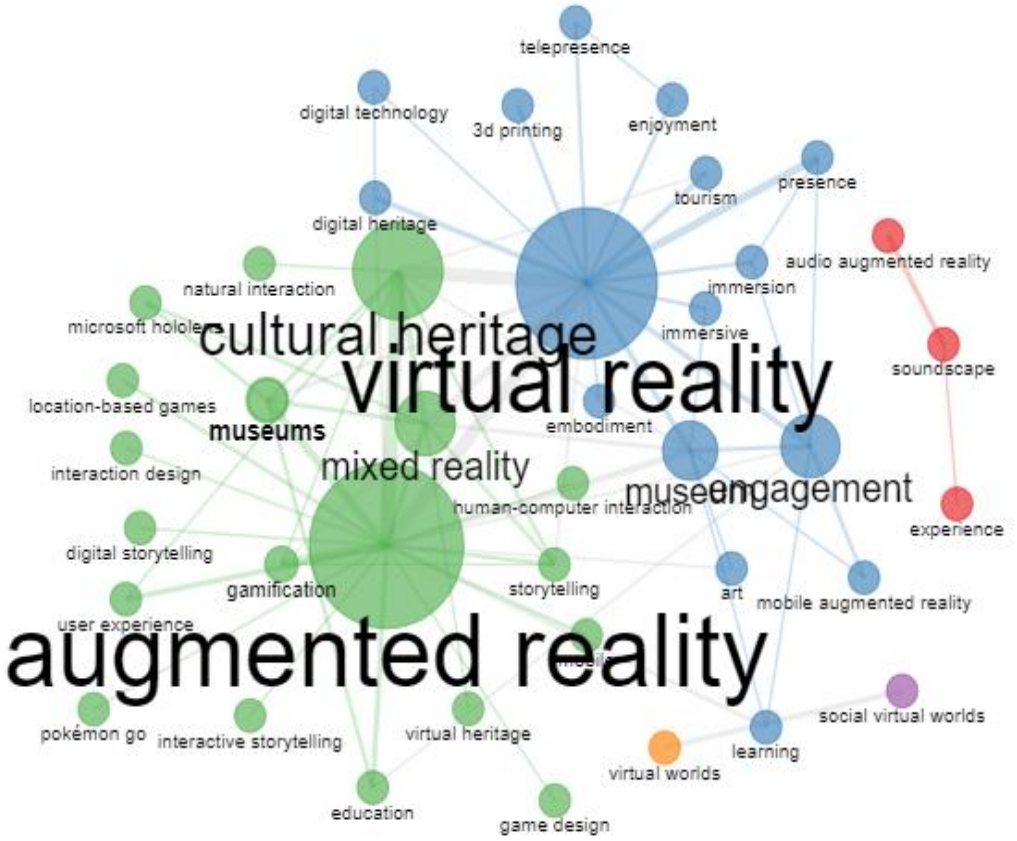

Figure 1. Co-occurrence network of keywords

These clusters significantly influence emerging VR/AR research. From the AR cluster, AR boosts young tourists' engagement in cultural events (Liang and Elliot, 2021). It immerses them in authentic cultural settings, and contributes to forging emotional bonds with sites (Gupta *et al.*, 2020), suggesting that research should target AR and Mixed

Reality (MR) mobile applications efficacy to foster social interactions (Bekele, 2021). The "engagement" cluster greatly impacts the adoption of immersive technologies. This cluster promotes emotional bonds with destinations for tourists and boosts satisfaction and loyalty regarding destinations (Ramos *et al.*, 2022). It illustrates TE's wide appeal associated with VR/AR across tourist groups (Bekele *et al.*, 2021). The "VR" cluster may guide research on value co-creation (Dieck *et al.*, 2018) and improve engagement in tours and heritage sites. This impacts the adoption of 360-degree virtual tours, thus enriching TE with unique experiences (Hofman *et al.*, 2022). Virtual tours enhance tourist-destination collaborations by boosting engagement (Gupta *et al.*, 2020). The "cultural heritage" cluster suggests that virtual technology boosts cultural learning (Bekele *et al.*, 2021). When used within 'cultural heritage' sites, virtual technologies can elicit memorable experiences and awareness, thereby fostering cultural learning (Shahab *et al.*, 2022). The "mixed reality" cluster highlights MR technology's role in TE and in the preservation of heritage sites (Soto-Martin *et al.*, 2020). The MR cluster depicts its role in boosting engagement within heritage sites. MR blends physical and digital elements for an immersive experience (Hammady *et al*., 2021). The "museum" cluster points to research on destinations such as dark tourism and wildlife sites (Lewis *et al.*, 2021), which can elicit an emotional connection/bond between tourists and destinations (Lewis *et al.*, 2021).

VR technologies promote TE (Loureiro *et al.*, 2020), suggesting a solid link between VR and engagement. VR/AR technologies intensify emotional and engagement levels at heritage sites (Shahab *et al.*, 2022).

Tourists adopt VR/AR mobile applications given their ease of use and interactive features (Nejad *et al.*, 2022). Although mobile applications like Travel World VR and AR Wild

promote tourism sites (Liang and Elliot, 2021), limited research in TE through VR/AR highlights their impact on visitation intention.

The TCCM analysis

The TCCM analysis covered 97 Scopus articles with authoritative insights on VR/AR technologies in TE research (Nova-Reyes *et al.*, 2020). The findings respond to RQ3.

Theories

A theory explains specific research phenomena (Bec *et al*., 2021). While most articles lacked theoretical foundations, 15.5% used at least one, predominantly the Technology Acceptance Model (TAM) (e.g., Hammady *et al.*, 2021). TAM posits that perceived usefulness and perceived ease of use influence technology acceptance (Hammady *et al.*, 2020). Only 3.1% used the Unified Theory of Acceptance and Use of Technology (UTAUT), suggesting that behavioral intentions drive technology use (Rauscher, 2021). The concept of engagement has three dimensions: cognitive, emotional, and behavioral (Hao, 2020; So *et al.*, 2020). The usefulness and ease of use of VR/AR in tourism are associated to TE (Iftikhar *et al.*, 2022). VR/AR not only heightens emotional and cognitive engagement, but also enhances perceived usefulness and ease of use of reality technologies. Studies using TAM reveal that cognitive engagement via VR/AR increases self-efficacy and influences perceived usefulness and perceived ease of use. The accessibility features of VR/AR enable disabled/handicapped people to enjoy virtual tourism. The UTAUT2 model expands UTAUT by introducing variables affecting user behavior (Alghatrifi and Khalid, 2019), but none of the articles we analyzed cited it. This model emphasizes cognitive and hedonic factors and can clarify TE in VR/AR research. It addresses hedonic motivations, which are crucial for tourist satisfaction (Wu *et al.*, 2023). VR/AR mobile applications influence tourists' hedonic experiences, aligning with

the emphasis of UTAUT'2 on hedonic motivation. VR/AR-based mobile applications foster responsible tourism, help preserve a destination's heritage and authenticity (Samaddar and Mondal, 2023). Such a reality enhances sustainable tourism through hedonic experiences (Hofman *et al.*, 2022). Our findings also emphasize the relevance of the Theory of Planned Behavior (TPB) in explaining TE via VR/AR.

The Information Exchange Theory (IET) was the third most mentioned theory (e.g., Yung *et al.*, 2021a), indicating that culture, policy, and social factors influence sharing attitudes.

Context

The study contexts were examined to identify prevalent TE research settings (Jiang *et al*., 2022). 54.6% of the papers focused on cultural heritage sites like museums, 30.9% on tourist sites like hotels, and only one on theme parks. VR/AR technologies foster emotional ties and cultural learning at heritage sites (Guo *et al*., 2021). These sites offer unique, authentic experiences, thus intensifying TE and drawing tourists keen on regional cultural history (Fan *et al.*, 2022). Heritage sites provide immersive and memorable tourist experiences (Guo *et al.*, 2021). Although 85% of papers surveyed tourism settings, few rank among the Top Ten papers focused on tourism and hospitality sources. This disparity might stem from computer science (Verma *et al.*, 2022), with tourism experts still not fully recognizing the potential of VR/AR in amplifying TE at these venues.

Our research underscores the scarcity of studies on TE at emotionally intense sites like dark tourism and wildlife destinations (Singh and Dhir, 2019). Dark tourism refers to places linked with death and tragedy, offering unique learning experiences (Lewis *et al*., 2021). Despite its potential to boost tourists' well-being, no studies explored TE through VR/AR in wildlife tourism(Curtin, 2005).

Previous TE research mainly focused on VR/AR's value perception (Yung *et al.*, 2021b). However, the visit intention factor is overlooked. The impact of VR/AR on cultural learning, engaging entertainment, and casual interest warrants deeper exploration.

Exposure to VR/AR (Wu and Lai, 2023) can activate passive and active TE, thus promoting responsible travel. This suggests that VR/AR mobile applications add value to eco-aware tourists and those with disabilities (Samaddar and Mondal, 2023).

TE Characteristics

TE characteristics concern dimensions, antecedents, and outcomes of VR/AR-enhanced TE, notably context awareness (Singh and Dhir, 2019). This section outlines these traits in VR/AR research, detailing independent and dependent variables. Our review focuses on perceived aggregate exposure, context awareness, and enjoyment. These factors bolster TE via VR/AR, fostering profound emotional and memorable experiences (Jiang *et al.*, 2022). Perceived aggregate exposure heightens TE by sparking novelty and interest in destinations (Spence *et al.*, 2022). Context awareness amplifies TE through immersive, personalized experiences, fostering social interaction (Hofman *et al.*, 2022). Enjoyment boosts TE by motivating tourists to share their experiences (Shahab *et al.*, 2022). Most virtual technology TE research centers on visitors and emotional engagement. Researchers should consider 'social engagement' and 'sustainability' concepts/variables.

Research targets keywords that capture valuable attributes of VR/AR, reflecting tourists' emotional ties and engagement (Trunfio *et al.*, 2022). This underscores the need of tourism research to probe into how VR/AR's emotional, social, and immersive aspects impact visit intention.

Methods

This section outlines the dominant research methodologies used in TE research. Our findings have revealed that systematic reviews and surveys dominated research designs. Case studies and experiments were also frequent, with the former providing deep insights into VR/AR tourism. This approach evaluates how VR/AR boosts TE at unique tourist and heritage sites. Mixed research, quasi-experiments, and interviews were less commonly used. Text mining, a method of converting vast unstructured text into structured data (Rita *et al.*, 2022), enhances our understanding of TE via VR/AR. It efficiently uncovers insights and introduces fresh perspectives (Furtado *et al.*, 2022).

Table I presents TCCM findings.

Table I - *Summary of TCCM findings*

Theory	Number of Articles	% of Articles	Examples
Technology Acceptance Model (TAM)	5	5.2	Hammady *et al.* (2021).
Unified Theory of Acceptance and Use of Technology	3	3.1	Moriuchi and Murdy (2022)
Information Exchange Theory	2	2.1	Mäntymäki *et al.* (2021)
Uses and Gratification Theory	2	2.1	Shahab *et al.* (2022)
Memorable Tourism Experiences (MET) Theory	1	1.0	Jiang *et al.* (2022)
Theory of Technological Mediation	1	1.0	Swords *et al.* (2021)
Theory of Planned Behavior	1	1.0	Hofman *et al.* (2022)
Other Theories/No Theory	82	84.5	Bekele *et al.* (2021)
Context (Industry/Setting)			
Cultural heritage sites (i.e., museums and art galleries)	53	54.6	Shahab *et al.* (2022)
Tourism (i.e., hotels, travel, sightseeing)	30	30.9	Bec *et al.* (2021)
Theme parks	1	1.0	Oh and Kong (2022)
Other settings (i.e., Cultural visits, Education)	13	13.4	Guo *et al.* (2021)
Characteristics			
Virtual Technologies:			
Virtual reality	35	36.1	Rauscher (2021)
Augmented reality	29	29.9	Wei (2019)
Mixed reality	8	8.2	Hammady *et al.* (2020)
Other virtual reality technologies	25	25.7	Jiang *et al.* (2022)
Independent Variables:			
Perceived aggregate exposure	29	29.9	Spence *et al.* (2022)
Context awareness	27	27.8	Hofman *et al.* (2022)
Enjoyment	17	17.5	Shahab *et al.* (2022)
Others/combination of variables	24	24.8	Bekele (2021)
Dependent Variables:			
Visitor/TE	55	56.6	Fiocco *et al.* (2021)
Tourism/virtual experiences	32	33.0	Oh and Kong (2022)
Cultural learning	6	6.2	Shahab *et al.* (2022)
Other TE	4	4.1	Mäntymäki *et al.* (2021)
Methods			
Survey	21	21.6	Bec *et al.* (2021)
Systematic review	26	26.8	Palma *et al.* (2021)
Experiments	19	19.6	Yung and Khoo-Lattimore (2019)
Case study	20	20.6	Spence *et al.* (2022)
Other research methods	11	11.4	Jiang *et al.* (2022)

FUTURE RESEARCH

This section outlines future research directions for TE via VR/AR in tourism and hospitality based on gaps from our findings to respond to RQ4. The tourism sector's slow adoption of VR/AR could explain the limited number of publications in this area. Given their significance, upcoming studies should bridge this gap and spotlight strategic

industry opportunities to optimize the effects of these technologies (Yung and Khoo-Lattimore, 2019).

TE through VR/AR Research Theories

Existing TE research mainly uses technology theories like TAM and UTAUT, focusing less on cultural theories regarding TE evolution. Introducing cultural theories, particularly Symbolic Interactionism Theory and the Computation, Technology, and Culture Theory (CTCT), can elucidate VR/AR adoption at cultural sites (Jiang *et al.*, 2022). The Symbolic Interactionism Theory explores tourists' interpretations of virtual cultural experiences, while CTCT shows how VR/AR shapes new cultural expressions and boosts TE intentions. Future research should merge cultural and technological theories to detail users' perceptions on VR/AR. Factors like subjective norms deeply impact technology adoption behaviors (Huang *et al.*, 2019).

VR/AR Characteristics/Elements

Research on barriers to TE from virtual technologies is scarce. Studying technology-related insecurities and privacy can pinpoint TE and tourist technology acceptance risks (Moro *et al.*, 2019).

Future studies could focus on VR/AR mobile applications for tourism, which, due to technology advancements, may influence the tourism and hospitality sectors differently from wearable devices (Wei, 2019). Therefore, understanding TE intentions through these mobile applications is essential.

Virtual technologies include 360-degree virtual tours, 3D VR, and MR (Hofman *et al.*, 2022). VR/AR value perceptions can be amplified with 360-degree tours (Wagler and Hanus, 2018), which impacts TE by offering lifelike experiences (Hofman *et al.*, 2022) and boosting emotional engagement, especially among millennials (Willems *et al.*, 2019). These tours affect sensory experiences, such as hedonic responses to hotel meals (Crofton

et al., 2021), emphasizing the link between 3D technologies and sensory appeal. Future studies should explore how these tours shape affective TE, especially regarding presence and enjoyment. Furthermore, their impact on the intention to revisit deserves attention (Wu and Lai, 2022).

TE Research Context

Cultural heritage, such as museums and archeological sites, are global tourist attractions (Shahab *et al.*, 2022), which gives rise to overuse concerns. VR/AR technologies can mitigate damage risks (Garipağaoğlu-Uğur and Akova, 2022) by offering virtual experiences akin to physical visits (Shahab *et al.*, 2022), thus promoting site sustainability. Therefore, future research should probe into how TE, through virtual technologies, aids heritage site sustainability.

VR and AR in tourism present vast opportunities for practice-based research. Therefore, future TE studies should probe into their impact on event-based tourism, especially sports tourism and leisure (Santoso *et al.*, 2022). Given the reality of inherent engagement in sports events, VR/AR can amplify social interactivity due to their hedonic potential (Lee and Oh, 2022).

TE Research Methods

Tourism technology can analyze tourists' emotions and behavior. Future studies should use virtual technology for cultural learning. Big data, Artificial Intelligence (AI), and machine learning allow for in-depth insights into tourist actions, thus optimizing tourism experiences. They offer better predictive analysis than traditional methods and can extract ideas from social media and online reviews (Xu and Lv, 2022).

Social media reviews greatly influence tourist decisions (Santoso *et al.*, 2022*)*. Analyzing online reviews in eWOM can help marketers gauge TE success via VR/AR. eWOM reflects positive and negative tourist perceptions (Pereira *et al.*, 2023). Future research

should examine tourists' online review management and explore the effect of VR/AR on physical and virtual tourism regarding the TE dimensions. Bridging this gap could offer a deeper understanding of TE via the use of virtual technologies (Santoso *et al.*, 2022). Moreover, future research on TE through VR/AR research should examine tourists' evolving engagement and emotions. Longitudinal methods can assess these changes by highlighting key TE trends via the use of VR/AR (Singh and Dhir, 2019).

Table II lists potential VR/AR research topics in tourism and hospitality.

Table II - *Summary of Future Research Topics and Questions for Tourism and Hospitality*

Future Research topic	Research questions
Co-Occurrence analysis	1. How can AR provide TE value to new tourism segments? 1 (a). How does AR boost engagement of young tourists at cultural events? 1 (b). Through what mechanisms do AR engage young tourists in real destinations? 2. Which tourist demographics VR/AR research accommodate in TE? 3. How can VR/AR enhance cultural learning within "cultural heritage" venues?
Theories	1. How can UTAUT2 explain hedonic motivation's impact on TE? 2. How can cultural-related theories explain VR/AR-driven TE? 3. What 'cultural and technological' theories can study VR/AR-based TE in tourism/hospitality?
Characteristics	1. How can VR/AR research expand TE's focus using 'social engagement' and 'sustainability'? 2. How do VR/AR's 'emotion', 'social', and 'immersive' attributes affect TE intentions? 3. How can VR/AR enhance cultural heritage sites sustainability?
Context	1. How can VR/AR in TE research generate insights from diverse settings? 1 (a) Can VR/AR in TE explore emotionally intense sites like dark tourism? 1 (b) Can VR/AR in TE encompass sports tourism sites?
Methods	1. How can text mining enhance TE knowledge in VR/AR? 2. Can online experiments depict tourist decisions in virtual settings? 3. Can longitudinal studies effectively analyze TE's evolution in VR/AR?

CONCLUSIONS

This study offers insights into TE research evolution through bibliometric analysis and TCCM. It highlights research areas, most cited authors, literature gaps, and this topic's progression, spotlighting theories (TAM, UTAUT), characteristics (perceived aggregate exposure, context awareness, and enjoyment), context (cultural heritage sites), and methods (systematic review and survey) for a detailed overview of this dynamic field.

The bibliometric analysis revealed influential TE research articles from computer science engineering backgrounds. Tourism and hospitality scholars should engage more in this area for relevant insights into TE in this sector. TCCM indicates that the research leans on technology theory, such as TAM and UTAUT, for TE behavior in VR/AR contexts (Rauscher, 2021).

Theoretical Implications

This study expanded the literature on TE (e.g., Nejad *et al.*, 2022), the tourism experience concept (e.g., Jiang *et al.*, 2022), temporal and special boundaries (e.g., Santoso *et al.*, 2022), and human-computer interaction (e.g., Shahab *et al.*, 2022), by highlighting TE through VR/AR state-of-the-art. In essence, this study outlines the theoretical understanding of the field and sheds light on future research.

Practical Implications

Tourism and hospitality managers can use this study to grasp TE's current state-of-the-art via VR/AR. By using the created knowledge, managers can stay updated regarding the most recent trends and explore alternative platforms with VR/AR to promote TE, thus enhancing tourists' experience, satisfaction, and loyalty (Verma *et al.*, 2022). Additionally, researchers can use this valuable knowledge to redirect their research efforts and as an immediate reference from where to develop their work.

Limitations

Our study has several limitations: 1) the review has only included the papers retrieved from the Scopus database; 2) limiting the search to 'title', 'abstract', and 'keywords' only in the review may exclude important TE studies; 3) using citation count to evaluate TE studies may be unreliable, as factors besides scholarly reputation can influence citations; 4) TCCM has focused on VR/AR papers only. Future studies can enhance the research by including other virtual technologies, such as the Metaverse. Finally, the approach narrowly focuses on four research areas (i.e., theory, context, characteristics, and methods), neglecting other important aspects like result presentation.

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Annexes

Annex I Search Keywords

Term	Query	References
Virtual Reality	(("virtual reality" OR "virtual world" OR "virtual environment" OR "VR "))	Loureiro et al. (2020) Yung and Khoo-Lattimore (2019) Liang and Elliot (2021) Moro et al. (2019)
Augmented Reality	(("Augmented Reality" OR "AR"))	Loureiro et al. (2020) Liang and Elliot (2021) Moro et al. (2019)
Tourism and Hospitality	(("tourism" OR "travel" OR "hospitality" OR "hotel" OR "accommodation" OR "restaurant" OR "catering" OR "airline" OR "destination" OR "attractions" OR "cultural heritage " OR "museum" OR "leisure "OR "tourist "OR "art gallery"))	Hao (2020) Moro et al. (2019) Loureiro et al. (2020) Wei (2019)
Tourist Engagement	(("engagement" OR "engage"))	Hao (2020) So et al. (2020)

Our search query limited the search to "title, abstract, and keywords", using Boolean operators "AND/OR". Only "Articles" were included in the TCCM analysis (97), as articles represent the latest and most advanced knowledge (Nova-Reyes et al., 2020). The search was performed on March 28, 2022, without time constraints to capture the broadest literature scope (Moher et al., 2009). Of the initial 653 retrieved documents, we excluded duplicates, non-English documents, letters, and short surveys, narrowing it down to 645 papers. The data were saved in a CSV file. To determine relevance, each author individually analyzed the titles and abstracts of the 645 documents, recording their opinion in the CSV file. The articles subsequently received unanimous approval or rejection by the authors, and any doubts were addressed in team discussion until consensus was reached. During this evaluation, we relied on three criteria to reject the documents: documents unrelated to VR/AR, focused on other technologies; systematic reviews on social interaction and experiences unrelated to tourism and hospitality; and articles not centered on the virtual environment, more focused on social media or physical

settings. These criteria ensured the inclusion of pertinent documents aligned with our research topic.

Annex II shows scholarly publications, with 236 papers published and cited 2,022 times — an average of 10.75 citations per paper. The years 2019, 2020, and 2021 recorded the highest number of publications: 36, 36, and 43, respectively. The average of total citations (TC) per year was 1.63; and per article was 10.75. In 2018, there were 341 citations, the highest number of citations. The most influential works were by Dieck *et al.* (2018), with 67 citations; Machidon *et al.* (2018), with 51 citations; and Schott and Marshall (2018), with 41 citations. Dieck *et al.* (2018) examined AR's effect on tourists' satisfaction, memory, and engagement with science at science festivals. These three articles investigated how VR/AR technologies can enhance the learning experience within cultural heritage settings. Furthermore, these authors acknowledge the importance of the immersive environment in the users' interactive experience and engagement. The pace of publication has increased since 2011, with an annual growth of 15.15%. Publications ranged between one and two from 2005 to 2009. The number has significantly increased since 2013. The highest number of publications was 43 in 2021, which reveals the growing interest of researchers in this topic. The increased number of publications is attributed to several factors. There have been considerable advancements in technology, which have resulted in the widespread adoption of mobile devices (smartphones and tablets) (Verma *et al.*, 2022). Moreover, movement restrictions as part of the COVID-19 containment measures led researchers to investigate how virtual technologies can promote virtual tourism (Meng *et al.*, 2022). The growing prominence of the tourism sector, coupled with the evidence that these technologies can enhance TE, has led to an increasing research interest (Verma *et al.*, 2022). Furthermore, a surge in research publications can be attributed to the availability of data on this topic (Jiang *et al.*, 2022).

Annex II

Scientific Production

Year	N	TC*	Mean TC* per Article	Mean TC* per Year	Citable Years
2005	1	12	12.00	0.63	18
2006	1	0	0.00	0.00	17
2007	2	24	12.00	0.80	16
2008	1	13	13.00	0.93	15
2009	1	1	1.00	0.08	14
2010	0	0	0.00	0.00	0
2011	3	118	39.33	3.58	12
2012	6	161	26.83	2.68	11
2013	11	288	26.09	2.37	10
2014	12	164	13.67	1.71	9
2015	16	99	6.19	0.88	8
2016	13	91	7.00	1.17	7
2017	20	190	9.50	1.90	6
2018	23	341	14.83	3.71	5
2019	36	262	7.28	2.43	4
2020	36	153	4.25	2.13	3
2021	43	102	2.37	2.37	2
2022	11	3	0.27	0.16	1
Total	236	2022	8.57	0.48	

TC*= Total Citations

Annex III shows that the Lecture Notes in Computer Science (LNCS) was the most prolific source, with the highest *h*-, *g*-, and *m*-indexes (21 documents and 201 citations). The LNCS had the highest h-index, which reflects the significant impact of its publications and the prominence of its computer science researchers in advancing the field, underlining its value as a resource for the computer science community. The LNCS covers computer science and features articles on the latest technologies and advancements in the field (Springer Nature, 2022). The *Journal on Computing and Cultural Heritage* is the second most ranked, with five publications and 46 citations. Of the Top 10 most productive sources, seven are journals, and three are conference proceedings. Eight sources focus on computer science. There is a link between these two aspects (i.e., computer science journals and publications on TE through VR/AR research), given that

these technologies create immersive environments by using computer systems and applications (Leung *et al.*, 2022). Five sources rank in Scopus Q1, with four focusing on computer science and one on social sciences, which indicates the topic's significance. Surprisingly, the sources do not yet consistently address the tourism and hospitality sectors. This might be attributed to several factors, namely the fact that VR/AR technologies are still a novelty in the tourism and hospitality sectors, or that the potential benefits of these technologies in these sectors are yet to be recognized (Verma *et al.*, 2022), or even that their slow adoption in the tourism field may explain the limited interest among researchers.

Annex III

Top 10 Most Productive Sources

Sources	NP*	TC**	h-index	g-index	m-index	Scopus Quartile
Lecture Notes In Computer Science	21	201	6	8	0.6	2
Journal On Computing And Cultural Heritage	5	46	4	5	0.444	1
ACM International Conference Proceeding Series	4	31	3	4	0.333	-
Journal Of Cultural Heritage	4	77	3	4	0.6	1
Springer Series On Cultural Computing	4	15	3	3	0.429	-
Sustainability (Switzerland)	4	43	3	4	0.75	1
Computers In Human Behavior	3	214	3	3	0.25	1
Multimedia Tools And Applications	3	159	3	3	0.3	1
Proceedings Of The Digital heritage 2013	3	33	3	3	0.3	-
2015 Digital Heritage International Congress, Digital Heritage 2015	3	30	2	3	0.25	-

**NP= Number of Publications; **TC = Total Citations.*

Annex IV lists the Top 10 most productive and impactful authors. Mäntymäki, M. is the most productive author, with six publications, followed by Baker, E.J., and Zulkifli, A.N.,

with five publications each. Mäntymäki, M. is the most influential author, with 264 total citations, followed by Salo, J., with 170 total citations. Mäntymäki is an Information Systems Science Associate Professor at the Turku School of Economics in Finland (Mäntymäki, 2019). His research topic focuses on social and economic impacts of digitalization. His first published paper on the topic was "Teenagers in Social Virtual Worlds: Continuous Use and Purchasing Behavior in Habbo Hotel". This paper focused on how the continuous usage of virtual social worlds influences perceived enjoyment and usefulness among teenage tourists (Mäntymäki and Salo, 2011). Nevertheless, new authors are emerging in the TE research field via virtual technologies. Hammady, R. and Ma, M. began publishing in 2020 and have been cited 16 times.

Annex IV

Top 10 Most Productive and Impactful Authors

Most productive authors				Most impactful authors (Top 10)			
Author	**NP**	**TC**	**PY_start**	**Author**	**TC**	**NP**	**PY_start**
Mäntymäki M	6	264	2011	Mäntymäki M	264	6	2011
Baker EJ	5	19	2017	Salo J	170	2	2011
Zulkifli AN	5	19	2017	Hurst W	130	1	2013
Carrozzino M	4	69	2016	Van Wezel C	130	1	2013
Miller A	4	42	2012	Elinich K	121	1	2012
Nisi V	4	12	2015	Steinmeier C	121	1	2012
Allison C	3	36	2012	Tucker S	121	1	2012
Coelho A	3	30	2017	Wang J	121	1	2012
Hammady R	3	16	2020	Yoon Sa	121	1	2012
Ma M	3	16	2020	Jung Th	118	2	2018

NP = number of publications, TC = total citations, PY-Start = the year in which the first article was published

Annex V shows that Mäntymäki is the author of the three most cited papers (Mäntymäki and Riemer, 2014; Mäntymäki and Salo, 2011, 2013), which confirms him as the most prolific author. The article by Mäntymäki and Riemer (2014) is entitled "Digital natives in social virtual worlds: A multi-method study of gratifications and social influences in Habbo Hotel", while the article by Mäntymäki and Salo (2013) is titled "Purchasing

behavior in social virtual worlds: An examination of Habbo Hotel". These papers were published in computer science journals, which further enhances the relevance of VR/AR technologies in TE for computer science, not tourism and hospitality, thereby confirming the results presented in Table III. It is worth mentioning that although published in 2020, the work by Hammady and Strathearn (2020), entitled "Ambient information visualization and visitors' technology acceptance of mixed reality in museums", is already ranking among the Top 10 most cited articles, with 12 citations.

Annex V

The Top Ten Most Cited Articles

Author	Article	Source	TC	TCpY*
Mäntymäki and Salo (2011)	Teenagers in social virtual worlds: continuous use and purchasing behavior in Habbo Hotel	Computers In Human Behavior	114	9.5
Mäntymäki and Riemer (2014)	Digital natives in social virtual worlds: a multi-method study of gratifications and social influences in Habbo Hotel	International Journal Of Information Management	74	8.222
Mäntymäki and Salo (2013)	Purchasing behavior in social virtual worlds: an examination of Habbo Hotel	International Journal Of Information Management	56	5.6
Machidon et *al.* (2018)	Virtual humans in cultural heritage ICT applications: a review	Journal Of Cultural Heritage	34	6.8
Kennedy et *al.* (2013)	Exploring canons & cathedrals with open virtual worlds: the recreation of St. Andrews cathedral, St. Andrews day, 1318	Proceedings Of The Digital heritage 2013.	22	2.2
Nóbrega et *al.* (2017)	Mobile location-based augmented reality applications for urban tourism storytelling	Epcgi 2017 - 24th Encontro Português de Computação Gráfica e Interação	20	3.333
Carrozzino et al. (2018)	Comparing different storytelling approaches for virtual guides in digital immersive museums	Lecture Notes In Computer Science	18	3.6
Mantymaky and Islam (2014)	Social virtual world continuance among teens: uncovering the moderating role of perceived aggregate network exposure	Behaviour And Information Technology	16	1.778
Duguleana et al. (2016)	Time-travelling with mobile augmented reality: a case study on the Piazza dei Miracoli	Lecture Notes In Computer Science	11	1.571
Hammady and Strathearn (2020)	Ambient information visualisation and visitors' technology acceptance of mixed reality in museums	Journal on Computing and Cultural Heritage	14	1.634

* TCpY = Total Citations per Year