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What leads to better immersive experiences? The role of guidance and mobility in virtual reality museums

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ABSTRACT

Virtual reality (VR) is reshaping tourism as museums increasingly adopt it to create immersive visitor experiences. While presence is key to VR effectiveness, little is known about how interaction modes affect it. This study examines the impact of two elements −guidance and spatial mobility− on perceived presence in virtual museum visits. It also explores the psychological mechanisms involved and identifies autonomy as a positive driver and satiation as a limiting factor. Results show that guidance enhances presence although it slightly reduces autonomy, while spatial mobility has less of an effect. In turn, presence boosts perceived entertainment and informativeness and positively influences attitudes toward the destination and visit intention. This research helps to understand how interaction design in immersive environments shapes user experience and behaviour. It offers theoretical insights on presence drivers as well as practical implications for creating more effective, satisfying, and wellbeing-oriented VR experiences in tourism.

1. Introduction

Recent technological advancements are reshaping and enhancing the confidence with which individuals interact with products and services, shifting from blended realities towards fully immersive digital environments –commonly referred to as virtual reality (VR) or in broader terms, the *metaverse*. In VR, users can be completely isolated from the external world and fully immersed in a virtual environment (Xi and Hamari, 2021). Given the advantages of VR, such as unique virtual experiences, fewer time and space limitations when compared to physical reality, and the increasing availability of consumer-grade VR devices like cost-effective VR headsets, major global companies such as Google, Microsoft, Nvidia, and Shopify have also made significant investments in its development (Dwivedi et al., 2022; Walbank, 2023). VR enables users to explore immersive environments where they can work, learn, conduct transactions, pursue their interests, and socialize with others.

While the emergence of VR technologies has primarily been driven by technological innovation, their academic and practical relevance has rapidly expanded due to their growing number of applications across multiple domains. This progression reflects a broader shift towards hybrid environments in which physical and digital experiences converge, enabling more engaging and personalized forms of human-computer interaction. As a result, sectors such as entertainment and gaming, business and marketing, education and training, as well as healthcare, hospitality and tourism have begun to integrate metaverse-based tools to enhance user experiences as well as improve cognitive and emotional outcomes. In marketing and retailing, retailers and brands increasingly employ virtual reality and metaverse environments to design interactive and emotionally rich shopping experiences, thereby fostering deeper engagement and strengthening the consumer-brand relationship (Ketron and Cowan, 2025; Uysal et al., 2025). In education and training, VR technology helps learners to acquire new skills and to develop information literacy through more immersive and interactive experiences (Wiepke and Heinemann, 2024; Wang et al., 2024). In healthcare, VR-based applications are used for pain management and psychotherapy (Riva, 2022) as well as for treating emotional and behavioural disorders (Laine et al., 2025).

In addition to these areas, another domain in which the adoption of immersive technologies is having a strong impact is the tourism industry. This influence is so significant that a wide range of tourism experiences have already incorporated immersive elements into their offerings (Dwivedi et al., 2022; Han et al., 2017; tom Dieck et al., 2016). These experiences are not only integrated within visits to specific attractions at the destination but also serve as communication tools that

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enable a pre-visualization of travel experiences (Martínez-Molés et al., 2022). One instance where the metaverse is expanding –particularly through VR experiences– is in museum and exhibition visits (Trunfio et al., 2022; Alabau et al., 2024; Li et al., 2024) where culture, art, history, and science have found a new platform in which to immerse visitors in engaging and interactive experiences. VR not only enables immersive virtual tours that eliminate travel barriers but also enhances storytelling and creates engaging narratives that deepen and enrich visitor understanding.

Institutions such as the Louvre in Paris, the Natural History Museum in London, and the Petersen Automotive Museum in Los Angeles now offer these types of virtual experiences (Richardson, 2024). Such virtual experiences go beyond virtual tours, and offer historical recreations (e.g., immersive visits to Tutankhamun's tomb or the interior of the Titanic), artistic recreations, such as stepping inside a painting (e.g., *Van Gogh's Palette* by The Musée d'Orsay) or a painter's workshop (e.g., *Modigliani VR: The Ochre Atelier* by London's Tate Modern), and even fantasy worlds (for instance, in theme parks like Disneyland and Universal Studios).

When assessing the effectiveness of VR experiences, one of the most critical variables is the sense of presence (Stracke et al., 2025; Slater and Steed, 2000; Weech et al., 2020). Several studies have shown that the stronger an individual's feeling of truly being in the virtual environment –while momentarily forgetting their physical surroundings– the greater the impact on emotional response and behavioural intention (Yung et al., 2020). In tourism, the sense of presence also emerges as a key determinant (Sylaiou et al., 2010; Tussyadiah et al., 2018; Wei et al., 2019). For instance, it enhances the perception of authenticity in virtual experiences (Li et al., 2024), fosters positive attitudes towards the destination and engagement (Alyahya and McLean, 2022; Fan et al., 2022), increases visit intention (Alyahya and McLean, 2022; Ying et al., 2021; Di Dalmazi et al., 2024; Zhu et al., 2024a), and contributes to users' overall subjective well-being (McLean et al., 2023). The literature has also explored the conditions that help boost the sense of presence in virtual tourist environments. It has been shown that the sense of presence is achieved to the extent that individuals perceive vividness (Liu and Tian, 2024; Zhu et al., 2024a, 2024b) and experience greater immersion (Yung et al., 2020) as well as mental imagery (Alyahya and McLean, 2022).

Although some authors have highlighted how the quality of mediated environments can enhance the sense of presence (Cummings and Baileson, 2015), there are also challenges associated with interacting in these environments, such as exhaustion, cybersickness or information overload (Hennig-Thurau et al., 2023; Juárez-Varón et al., 2023). These issues are primarily caused by a mismatch between visual stimuli and sensory feedback (Gavgani et al., 2018), leading to user discomfort that may result in a desire to avoid interaction –ultimately reducing the sense of presence and negatively affecting overall well-being. This underscores the importance of exploring how different modes of interaction within VR can stimulate presence and of understanding through which psychological responses this occurs. In this regard, Dwivedi et al. (2022) emphasize the need to examine how design might influence user responses in the metaverse.

To address this gap, and in order to help understand user experience in VR within the context of museums and exhibitions, this study explores how the design of VR interactivity can enhance the sense of presence. We focus on two key elements commonly found in traditional museum visits, but applied here to virtual tours: guidance, and spatial mobility. In real-world settings, museums and exhibitions provide visitors with guided tours or orientation materials to structure their visit. At the same time, visitors have the freedom to explore different spaces and exhibition rooms at their own pace. Building on this idea, this research seeks to analyse to what extent VR interactivity regarding system-provided guidance (external interactivity –to what degree a VR system provides external information, instructions, and feedback) and user-driven movement (internal interactivity –to what degree user control over their movements and navigation) would make virtual visits more similar to real-life experiences and enhance the sense of presence. Incorporating cues to guide users or allowing greater freedom of movement are easily adjustable interaction design features that can influence perceived presence and, consequently, enrich the overall experience and lead to behavioural responses.

Additionally, from the perspective of the Approach-Avoidance Theory, this study examines how these features impact perceived autonomy and satiation, such that these variables mediate the effect of guidance and spatial mobility in the sense of presence. We also consider that interaction will influence presence insofar as it stimulates an approach response through positive sensations and, specifically, the feeling of autonomy in decision making and actions. Entering VR and navigating an unfamiliar space may cause fatigue or exhaustion due to the constant need to remain alert in a reality that users are not accustomed to. The sense of presence will thus be greater if negative sensations, such as satiation, are avoided. Finally, this study investigates how presence –as shaped by interactivity choices– influences users' overall experience in terms of entertainment and informativeness, as well as the attitude towards the physical destination and the intention to visit it.

Our study contributes to a deeper understanding of the interaction design in virtual visits within the metaverse, and offers valuable insights into how immersive experiences can be designed to minimize user discomfort, reduce interaction fatigue or satiety, and enhance the perception of autonomy within the experience. These psychological responses in turn help to optimize user presence and, ultimately, enhance overall user experience as well as users' attitudes and intentions. Specifically, our results demonstrate that the inclusion of a guide significantly reduces the perception of satiety and boosts the sense of presence, albeit with a slight reduction in perceived autonomy. In contrast, spatial mobility is seen to have little direct influence on presence. Additionally, our findings underscore the pivotal role that presence plays in shaping user attitudes towards the destination and user intention to visit, particularly by providing greater entertainment and informativeness.

2. Conceptual background and hypotheses development

2.1. VR tourism

Although VR remains more of a theoretical vision than a commercial reality in many industries, its tangible presence in tourism is already evident (Loureiro et al., 2020; Buhalis et al., 2023). This sector has previously undergone major transformations with the advent of the internet, social media, and smartphones, which have reshaped traveller behaviour (Buhalis, 2020). Now it is extended reality that is becoming a key component of the tourism industry, with the World Economic Forum (2022) recognizing immersive technologies as one of the areas with the highest growth potential.

Virtual reality enhances the tourist experience at a destination by offering complementary activities that allow visitors to explore and enjoy different aspects from new perspectives. In VR, the physical and digital worlds converge, allowing for a seamless transition between them. It can thus offer innovative ways to engage with art and history by affording access to spaces that are impossible to visit physically (for instance, the capitals or vaults of a cathedral), historical recreations (for example, the reconstruction of ancient Rome), or artistic recreations, such as artists' workshops from different historical periods (Dwivedi et al., 2022).

The impact of VR on tourism extends beyond merely enhancing on-site experiences. VR can act as a pre-trip technology in shaping consumer decisions, thereby enabling users to anticipate and plan their on-site experience, with tourists being able to preview destinations and services before their trip (Kostyk et al., 2024; Loureiro et al., 2020; Martínez-Molés et al., 2022; Rauschnabel et al., 2022). Immersive environments allow potential travellers to virtually explore destinations and services through experiences that closely resemble those of the physical world (Buhalis and Karatay, 2022). Indeed, travel planning is one of the areas most affected by the incorporation of digital twins. By virtually exploring locations and activities, users may feel inspired to visit these places in person, with the immersive experience even influencing their decision-making process (Buhalis and Karatay, 2022; Buhalis et al., 2023; Calisto and Sarkar, 2024; Martínez-Molés et al., 2022).

2.2. Sense of presence in tourist immersive environments

Sense of presence is a key concept in understanding the effectiveness of VR (Stracke et al., 2025; Sylaiou et al., 2010; Tussyadiah et al., 2018; Wang et al., 2025), and is defined as a psychological state in which an individual becomes so immersed in a computer-mediated environment that they feel themselves "actually being there" (Alyahya and McLean, 2022; Slater and Steed, 2000; Weech et al., 2020). Presence represents the moment when the artificial aspect of virtuality fades into the background and goes unnoticed (Lee, 2004). The level of presence that a user experiences when interacting with such a system thus depends on the extent to which they feel transported or perceive a seamless transition from their physical world to a virtual one (Wei et al., 2019). Although some studies have highlighted the importance of immersive experience design in fostering presence (Weech et al., 2020; Tussyadiah et al., 2018; Wei et al., 2019), it is also essential to understand how presence is created and what tools tourism experience designers have at their disposal to improve it.

In tourism literature, several studies have examined the mechanisms that contribute to a sense of presence. Yung et al. (2020) theoretically propose three conditions that enhance the sense of presence in a virtual environment: immersion, sensory fidelity, and user engagement. These conditions are achieved through features and specifications that simulate the real world and that influence sensory stimulation, ultimately leading to user isolation, immersion, and a shift in experience from the real world to the fictional world.

At an empirical level, Alyahya and McLean (2022) focus on VR's ability to construct mental imagery in the consumer's mind as a precursor to presence –an effect that is reinforced by a sensory-rich VR experience. In this regard, more recent studies have focused on one dimension of mental imagery; the vividness of the images shown to tourists in VR (Liu and Tian, 2024; Zhu et al., 2024a, 2024b) or in media content, specifically VR's capacity to present destination-related information (Yu et al., 2024). Other conditions that enhance the sense of presence include tourist participation or interaction within immersive environments (Liu and Tian, 2024; Li et al., 2024) as well as perceived control and perceived autonomy, meaning the tourist's freedom to explore and make decisions (Liu and Tian, 2024; Li et al., 2024).

All these studies suggest that presence in VR is achieved through the user's prior psychological states which in turn depend on design features. Various design elements such as the storyline, environment design, quality, and how seamlessly the experience is designed to ensure smooth and enjoyable user interaction, are seen to contribute to immersive experiences (Han et al., 2023; Lee et al., 2020b). However, as Yung et al. (2020) point out, the features and technical design required to provide immersion and achieve presence in VR are highly context dependent. Building on this idea, this research focuses on the context of museums and exhibitions in order to explore specific features of VR that enable visitors to experience a greater sense of presence and, consequently, respond at multiple levels: affective (entertainment), cognitive (informativeness), attitudinal (attitude towards the destination), and behavioural (intention to visit).

2.3. The impact of VR interactivity on the sense of presence: guidance and spatial mobility

As mentioned, enhancing the sense of presence in immersive virtual environments depends on interactivity characteristics. Although the design of virtual experiences in the museum context has been explored (Lee et al., 2020b; Puig et al., 2020; Shahab et al., 2023; Sánchez-Amboage et al., 2023), interaction with virtual reality itself has been less studied, despite being a key feature in the smooth integration of this technology (Gong et al., 2020). To address this shortcoming, this study examines two distinct forms of interaction, which we refer to as external and internal to the user. External interaction is represented by guidance, which refers to the extent to which the VR system provides the user with external information, instructions, and feedback. Internal interaction is represented by spatial mobility and refers to the degree of control users have over their own movements and navigation within the virtual environment.

Guidance. Due to its novelty, many users may feel uncertain when interacting with a VR environment (Flavián et al., 2024). The overwhelming amount of information presented can lead to cognitive overload, causing users to lose focus on the content (Chen et al., 2023a; Juárez-Varón et al., 2023). To address challenges such as information overload and cognitive processing difficulties, researchers have suggested incorporating guidance systems or visual cues (Jaud et al., 2023). In a museum setting, this concept is comparable to an on-site tour guide (Holloway, 1981), which helps visitors navigate the space rather than leaving them to determine the best viewing order for exhibits on their own. Just as museums and exhibitions provide visitors with various options to guide them through the tour (such as tour guides, audio-guides, or informational panels outlining the suggested route), virtual museum experiences can also be designed in this way.

Indeed, the need to provide guidance for visitors in VR is a challenge that video game designers have already encountered. Video games often face the issue of engulfing and overwhelming players when leaving them unsure of what to do next. To counter this, many games integrate in-game guides or companions. These assistive systems accompany players throughout their journey and play a crucial role in the game's success (Kim et al., 2016).

Having a guidance system within VR can thus help to mitigate information overload by guiding users step by step and by incorporating tips and hints (Jaud et al., 2023). This approach could also enhance users' sense of being there in the virtual environment by making the experience more engaging and intuitive (Hansen and Mossberg, 2016). Incorporating these types of guides can also enhance perceived presence by allowing users to focus on their actions rather than being distracted by other stimuli within the virtual environment. We thus propose the following hypothesis:

H1: Guidance in virtual reality has a positive effect on the sense of presence.

Spatial mobility. One of the defining elements of a museum or exhibition visit is the visitor's journey; in other words, walking through different rooms or galleries. This real-world experience of moving through a space on foot has not always been replicated in virtual experiences. When designing virtual environments that require users to move from point A to point B, the available locomotion options are limited. Among them, "click and teleport" has become the most widely adopted method. This paradigm –often simply referred to as "teleportation"– is frequently used in VR games and online VR communities (Banakou and Slater, 2023). Although teleportation is the most commonly used method due to its convenience (Prithul et al., 2021), it remains inferior to natural walking (Cherep et al., 2020), with the latter being associated with a stronger sense of immersion (Banakou and Slater, 2023) and greater perceived naturalness (Nabiyouni et al., 2015). Some studies have even shown that teleportation can reduce the feeling of presence when compared to natural walking (Banakou and Slater, 2023; Nabiyouni et al., 2015). Additionally, physical mobility within VR environments generally has a positive impact on the user (Chung et al., 2024; Hennig-Thurau et al., 2023); the more realistic the movement, the more natural and enjoyable users perceive the experience to be (Nabiyouni et al., 2015).

For these reasons, we argue that the level of spatial mobility permitted in virtual environments impacts perceived presence, as natural movement fosters a stronger sense of being there. Allowing visitors full freedom of movement and enabling them to walk naturally within the VR museum will have a greater impact on the sense of presence than using controllers for movement or restricting movement to rotating in place or merely shifting their perspective (e.g., by turning their heads). Thus:

H2: Spatial mobility in virtual reality has a positive effect on the sense of presence.

2.4. Visitors' psychological responses: satiation and autonomy

From the perspective of the Approach-Avoidance Theory (Russell and Mehrabian, 1978), people are drawn to environments in which they experience pleasure and a moderate level of arousal, whereas they tend to avoid environments where they feel bored, unhappy, or extremely aroused. This theory has been applied to environmental psychology, since it explores how the emotions created by environmental stimuli can influence approach, avoidance, and affiliation behavioural responses (Arnold and Reynold, 2012; Clark et al., 2009). Based on this framework, we propose that in the virtual environment, individuals will be drawn to positive sensations –specifically, the perception of autonomy– while avoiding negative emotions –namely, satiation. In other words, the stimuli or design of the virtual environment (i.e., guidance and spatial mobility) will enhance the sense of presence to the extent that they promote autonomy and reduce the perception of satiation.

Perceived autonomy. The Self-Determination Theory posits that autonomy is one of the three basic psychological needs and it has been shown to be a predictor of human motivation (Ryan and Deci, 2000). In the context of VR, autonomy could be defined as the user's ability to freely explore the virtual environment. Autonomy is a desirable feature in the virtual environment because individuals have an inherent desire to make choices by themselves (Liu and Tian, 2024), such that VR users will be motivated to seek autonomy.

Individuals who perceive autonomy tend to experience an increased sense of control and freedom and, as a result, will be more immersed in the activity they are engaged in (Kim et al., 2016; Wei et al., 2019). Liu and Tian (2024) indicate that perceived autonomy in virtual environments leads individuals to make choices and decisions in the same way they would in a real environment. It makes them feel more authentically present within the virtual environment and heightens their sense of presence.

Although guidance has proven to be beneficial in environments where there is an overwhelming number of stimuli (Flavián et al., 2024), these guides essentially reduce the number of available choices for users, which might diminish visitors' sense of autonomy (Kim et al., 2016). Although incorporating guidance in the virtual museum experience may enhance the sense of reality and presence, it may also reduce users' sense of autonomy and, indirectly, have a negative impact on presence.

As for spatial mobility, having more space and not limiting users to a confined area will positively affect their perceived autonomy by allowing them to interact with the environment in a more natural way (Banakou and Slater, 2023; Cherep et al., 2020). This will permit them to move freely without depending on an external mechanism to navigate the space, which in turn will reduce the perception of artificiality in virtual environments and ultimately lead to a greater sense of presence (Lee, 2004). Following on from this, the following hypothesis is proposed:

H3: In virtual reality, perceived autonomy negatively mediates the relationship between guidance and the sense of presence (H3a) and positively mediates the relationship between spatial mobility and the sense of presence (H3b).

Perceived satiation. Not everything is positive when interacting with VR. There are also negative aspects that users will try to avoid (Buhalis et al., 2023; Dwivedi et al., 2022; Flavián et al., 2024). For example, users may experience fatigue or cybersickness, which is characterized by symptoms such as dizziness, headaches, or eye discomfort, and which are exacerbated by the use of virtual reality headsets (Hennig-Thurau et al., 2023). Additionally, there are the issues of information overload and of feeling overwhelmed, as previously mentioned (Chen et al., 2023a; Juárez-Varón et al., 2023; Flavián et al., 2024). These challenges could lead to increased mental fatigue and make individuals more likely to experience satiation.

Satiation is defined as the response to repeated exposure to a stimulus (McAlister, 1982). Its onset is linked to the consumption of the stimulus itself, although there are several factors that accelerate its appearance. Nelson & Redden (2017) showed that people become satiated more quickly when they use more cognitive capacity. In the context of tourism and museum visits, individuals are likely to experience fatigue and satiation when interacting with the physical environment (Jeong and Lee, 2006; Anton et al., 2018a), and when it occurs, visitors lose interest in the visit or the museum content (Anton et al., 2018b).

Due to the high cognitive demand involved in interacting with immersive elements, consumers will thus require more mental resources to maintain their attention, which could lead to an earlier onset of satiety. As a result, they will feel the need to stop consuming the content they are engaging with, thereby preventing the "teleportation" process from taking place, which will break their concentration and negatively impact perceived presence. A guide might help to reduce these issues of satiation by presenting individuals with information and steps in a more organized manner (Jaud et al., 2023), while controlling the amount of information they need to process at once (Flavián et al., 2024). This guidance helps to eliminate the information overload that triggers satiation, thus leading to an increase in engagement and presence.

Having more space to walk in removes the need to use artificial controls or the need to learn how to navigate a point-and-click system, which tends to cause greater feelings of dizziness (Cherep et al., 2020; Hennig-Thurau et al., 2023) and which can increase information overload. This is due both to the need to learn to manipulate these controls and because interaction has a less natural feeling to it (Nabiyouni et al., 2015). Moreover, allowing individuals to move freely instead of having to rely on these controls leads to an increase in presence by reducing feelings of satiation.

H4: In virtual reality, perceived satiation positively mediates the relationship between guidance and the sense of presence (H4a), and the relationship between spatial mobility and the sense of presence (H4b).

2.5. Outcomes of the sense of presence

Presence is often mentioned for its effectiveness and persuasive power (Calisto and Sarkar, 2024; Tussyadiah et al., 2018). A stronger sense of presence leads to more positive intentions or attitudes towards a given destination. Several authors have highlighted the significance of this factor in shaping behaviour and in forming attitudes (Alyahya and McLean, 2022; Bogicevic et al., 2019; Hudson et al., 2019; Lee et al., 2020b; Wei et al., 2019; Ying et al., 2021; Yung et al., 2020). Alyahya and McLean (2022) measured how attitude towards a destination improved through a greater sense of presence in a VR experience, while Wei et al. (2019) analysed how the feeling of presence in a VR roller coaster influenced the intention to revisit and recommend as well as general satisfaction. Considering the persuasive power and effectiveness of VR attributed to presence, a greater sense of presence will enhance the attitude towards the destination (i.e., the museum or exhibition) and the intention to visit it. This leads to the following hypothesis:

H5: Sense of presence in virtual reality positively influences attitude towards the (physical) destination (H5a) and visit intention (H5b).

Sense of presence also leads to other responses, such as enhanced customer experience (Bogicevic et al., 2019; Sylaiou et al., 2010). Indeed, one of the main aims of incorporating immersive technology into museums –and tourism in general– is to boost visitor experience (Cheng et al., 2023b; Flavián et al., 2019). Customer experience can be defined as the internal and personal responses to all direct and indirect stimuli encountered during interactions with a brand throughout the customer journey (Lemon and Verhoef, 2016; Silva et al., 2021). In the online context, customer experience has been conceptualized as a multidimensional construct (Bleier et al., 2018) composed of four dimensions: entertainment (affective dimension), informativeness (cognitive dimension), sensorial appeal (sensory dimension), and social preference (social dimension). In the present study, we focus solely on the affective and cognitive dimensions to characterize the experience in the virtual environment. We do not consider the sensory dimension, as our study uses the same technology (VR) and the same digital twin across conditions. While differences in sensory appeal are expected between technologies –such as VR and AR, as discussed by Orús et al., 2021–sensory inputs in our study remain the same across conditions. As regards the social dimension, we study a context in which the virtual visit is individual, without the presence of other visitors.

Users who feel present in an immersive environment will also perceive a better overall experience (Han et al., 2017; Lee et al., 2020a; tom Dieck et al., 2016; Ying et al., 2021). The more transported a user feels into the virtual world, the better their perceived experience will be. In other words, the deeper their presence in the environment, the more positively they will report their experience (Lu et al., 2012; Xi and Hamari, 2020). Several authors have highlighted that when users feel present in a technology-mediated environment, they experience greater entertainment and enjoyment (Lee et al., 2010; Sylaiou et al., 2010; Tussyadiah et al., 2018; Ying et al., 2021) and retain more information (Lee et al., 2010; Ying et al., 2021).

Furthermore, users who perceive greater entertainment or informativeness from interacting with an immersive tourism environment will develop a more positive attitude towards the destination (Ibáñez-Sánchez et al., 2022; Tussyadiah et al., 2018). Consequently, they are more likely to visit or revisit that destination in its physical form later (Ibáñez-Sánchez et al., 2022; Lee et al., 2020a; Tussyadiah et al., 2018).

Sense of presence in VR thus leads to a more positive attitude towards destinations and a greater intention to visit them, since a stronger sense of being there enhances perceptions of entertainment and information retention (Cuny et al., 2015; Tussyadiah et al., 2018). Based on this, the following hypotheses are proposed:

H6: The virtual tourist experience in terms of entertainment positively mediates the effect of presence on attitude towards the (physical) destination (H6a) and visit intention (H6b).

H7: The virtual tourist experience in terms of informativeness positively mediates the effect of presence on attitude towards the (physical) destination (H7a) and visit intention (H7b).

The model proposal is represented in Fig. 1.

3. Methodology

3.1. Design

A 2 × 2 between-subjects experimental design was implemented to test the hypotheses, manipulating guidance (present vs. absent) and spatial mobility (high vs. low). Participants were provided with a virtual tour experience of the Anne Frank House Museum through four different experimental conditions (see Fig. 2).

3.2. Participants

A total of 216 participants were initially recruited from a university in southern Europe. Participants who did not complete the questionnaire correctly were excluded from the analysis. The final sample consisted of 209 undergraduate students (M_{age} = 21.05, SD_{age} = 2.46; 59.3 % female), distributed across experimental conditions as follows: $N_{present guide+high space}$ = 51, $N_{present guide+low space}$ = 54, $N_{absent guide+high space}$ = 51, and $N_{absent guide+low space}$ = 53 (see Table 1). The sample of young adult students is considered suitable for the aims of this study, as this group is generally more accustomed to immersive environments (for instance, in video games) and to regular use of digital technologies. This facilitates their interaction with VR content and reduces the risk of usability-related barriers. In addition, a student sample contributes to internal validity due to its relative homogeneity in terms of age and educational level (Peterson and Merunka, 2014).

3.3. Material

The study was conducted using a digital twin of the Anne Frank House. Developed by Vertigo Games, this virtual replica faithfully recreates the furniture and layout of each room as they appeared during the period in which Anne Frank and her family were in hiding. The application can be downloaded from the Meta Store or from the official Anne Frank House website (https://www.annefrank.org). The experience allows users to complete the full visit within a short timeframe, thus ensuring that participants did not spend more than 30 min on the procedure. The virtual tour featured an interactive exploration of the house, where various elements revealed aspects of Anne Frank's story. The experiment was conducted using the Meta Quest Pro 2 virtual reality headset, paired with two controllers. These controllers were used consistently across all four experimental conditions. They were not only necessary for movement in the reduced mobility conditions but also for interacting with the various elements present in the virtual experience.

For guidance, two conditions were implemented. In the guided condition, participants followed a structured, chronological path. This route was marked by the interactive elements included in the virtual twin (represented either by objects inside the house or by icons

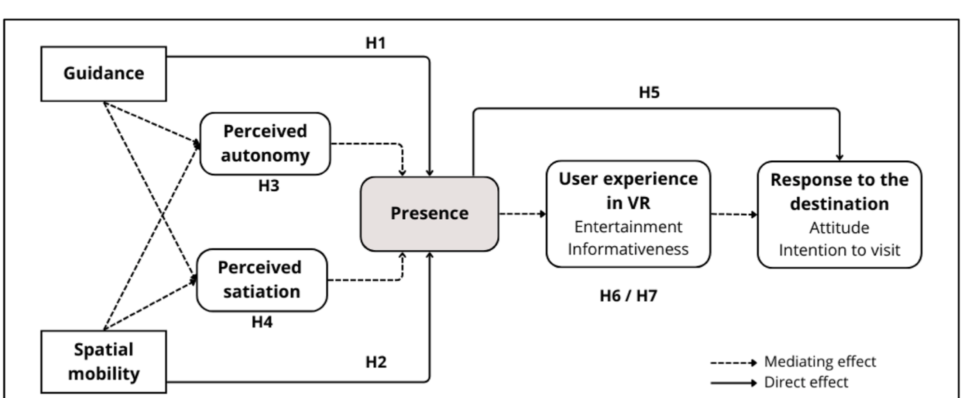

Fig. 1. Model proposal.

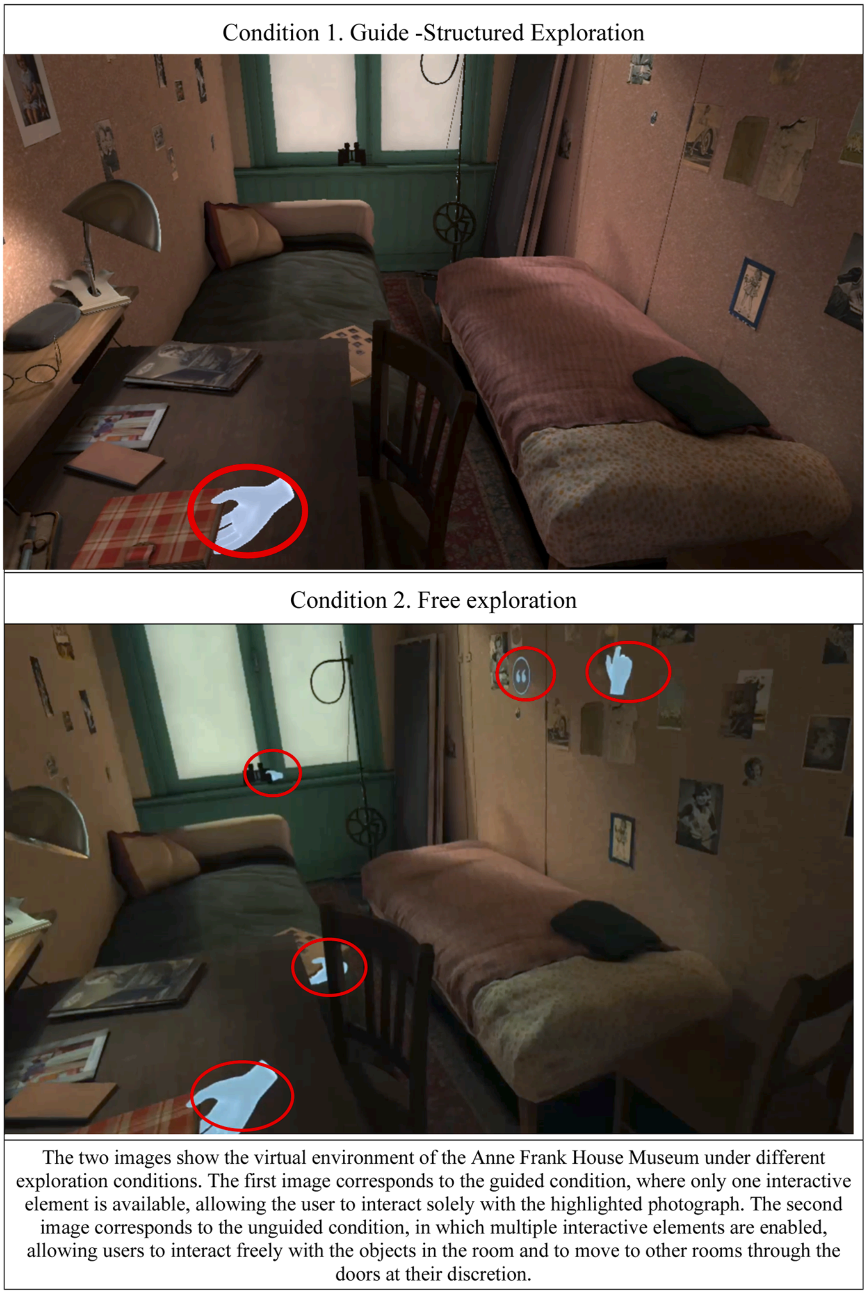

Fig. 2. The VR environment of the Anne Frank House.

Table 1
The 2 × 2 between-subjects experiment design and participant information.

Group	Guidance – Exploration mode		Spatial mobility – Motion techniques		Demographics
1 (n = 51)	Present	Structured exploration	Absent	Physical walk	Age: 20.92 (2.26)Female: 62.7 %
2 (n = 54)	Present	Structured exploration	Present	Teleport with controllers	Age: 21.65 (3.21)Female: 53.7 %
3 (n = 51)	Absent	Free exploration	Absent	Physical walk	Age: 21.65 (1.99)Female: 54.9 %
4 (n = 53)	Absent	Free exploration	Present	Teleport with controllers	Age: 19.98 (1.89)Female: 66.0 %

displayed on certain surfaces such as walls or doors). Only the next interactive element was illuminated and could be activated, which prevented participants from progressing until they had viewed it, thereby ensuring a strictly sequential exploration that is similar to a guided museum tour. For example, as shown in Fig. 2, a pointing hand indicated the interactive element and guided the user towards the next step of the visit. Conversely, in the free-exploration condition, participants had complete freedom to navigate the museum at their own pace and in any order, mimicking a self-guided visit. In this condition, all interactive elements were available from the beginning, allowing users to decide whether to engage with them and in whichever sequence they preferred.

Spatial mobility was also manipulated across two conditions: a high-mobility condition, where participants could move freely within a 20m^2 area, and a low-mobility condition, where movement was restricted to a circular space of less than one square metre. Since the space and places to visit within the house were the same, users in the reduced mobility condition had to use the controls to move through the system by using the click and teleport method.

Previously validated scales were used to measure perceived autonomy (Liu and Tian, 2024), satiation (Antón et al., 2018b), and sense of presence (Alyahya and McLean, 2022). User experience dimensions (entertainment and informativeness) were assessed using adapted items from Bleier et al. (2018), while attitude and visit intention were measured with adapted scales from Alyahya and McLean (2022). Additionally, user characteristics were included as control measures. We measured prior knowledge of the Anne Frank House (Knowledge AF), previous experience with VR (Experience VR), and previous experience with video games (Experience VG) We also took into account individuals' focus on the interactive elements during the visit (Focus interaction) as an indicator of the level of attention they paid to the task they had to perform (See Appendix A). All variables were measured using seven-point Likert scales (1 = "strongly disagree," 7 = "strongly agree"), except for attitude, which was assessed using a semantic differential scale based on the items from Alyahya and McLean (2022).

The internal consistency of the constructs is supported by Cronbach's alpha values that exceeded 0.80. Moreover, average variance extracted (AVE) for all constructs is above 0.70, and composite reliability (CR) surpasses 0.90. Convergent validity is established, with loadings exceeding 0.7. Likewise, discriminant validity is confirmed, as each construct's AVE square root is greater than its correlations with other constructs, and heterotrait-monotrait values are higher than 0′85 (see Appendix B).

3.4. Procedure

Participants were university students recruited through campus posters and a faculty website banner inviting them to take part in the experiment. No compensation was offered for participation. By booking a time slot, participants explicitly consented to take part in the study in accordance with the host university's Code of Good Practice in Research and Ethics. No personal or identifying data were collected at any stage of the study. Before the experiment began, all participants received detailed instructions on how to use the VR headset, the controllers, and the interactive elements of the immersive environment correctly. After that, each participant was randomly assigned to one of the four experimental conditions. Each participant spent 20 min inside the virtual environment, during which they visited the same rooms across all conditions. To ensure adherence to the protocol, a researcher continuously monitored participants' actions. If a participant appeared lost, minimal guidance was provided to help them proceed. Likewise, participants were allowed to pause or stop the experiment at any point if they experienced symptoms of motion sickness, although no participant did so.

After the immersive reality experience, participants completed a questionnaire (see Appendix A), which they accessed on their own mobile phones by scanning a QR code.

3.5. Results

Firstly, to test hypotheses H1 and H2 regarding the effects of guidance and spatial mobility on presence, an analysis of covariance (ANCOVA) was conducted, considering prior user experience with technology, experience with video games, and the level of attention to interactive elements as control variables. ANCOVA results showed that the effect of guidance on the sense of presence was significant ($F(1, 202) = 6.19$, $p = 0.014$), whereas the effect of spatial mobility showed little direct influence on presence, which was marginally significant at the 90 % confidence level ($F(1, 202) = 4.54$, $p = 0.080$). Although not part of the hypotheses, the interaction effect between guidance and spatial mobility was also estimated. However, the interaction effect was not significant ($F(2, 202) = 4.54$, $p = 0.443$).

In order to examine the rest of the hypotheses and the proposed mediating effects, we conducted serial mediation analysis using Hayes' PROCESS with 5000 resamples (Hayes, 2017). The results are presented in Tables 2 and 3.

As for H1 and H2, we again observe that guidance has a significant positive effect on the sense of presence ($\beta = 0.518$, SE = 0.107, $p = 0.000$) as well as spatial mobility ($\beta = 0.202$, SE = 0.099, $p = 0.041$), although this effect is lower. With regard to the mediating roles of autonomy and satiation, results show that the guide has a significant negative indirect effect on presence through autonomy ($B = -0.296$, SE = 0.074, 95 % CI: −0.450 to −0.157), thus supporting H3a. Interestingly, despite this negative effect, the total effect of the guide on presence remains positive ($B = 0.265$, SE = 0.107, 95 % CI: 0.056 to 0.475). Spatial mobility appears to have no indirect effect on presence through perceived autonomy ($B = -0.038$, SE = 0.034, 95 % CI: −0.114 to 0.019), leading us to reject H3b. As regards satiation, neither the guide ($B = 0.043$, SE = 0.030, 95 % CI: −0.060 to 0.112) nor spatial mobility ($B = 0.026$, SE = 0.029, 95 % CI: −0.022 to 0.094) seem to have significant indirect effects on presence through this variable, leading to H4a and H4b being rejected. It is also worth noting that, although no indirect effects were found through satiation, there is a significant direct negative effect of satiation on presence ($\beta = -0.147$, SE = 0.047, $p = 0.002$).

Examining the downstream effects of presence, we find that presence has a direct positive effect on attitude towards the destination ($\beta = 0.354$, SE = 0.122, $p = 0.004$), thus confirming H5a. However, presence has no significant direct effect on visit intention ($\beta = -0.158$, SE = 0.113, $p = 0.163$), leading us to reject H5b. As for the mediation effects of user experience, Table 2 indicates that the indirect effects of presence on attitude through user experience are significant for both entertainment ($B = 0.167$, SE = 0.070, 95 % CI: 0.049 to 0.330) and informativeness ($B = 0.091$, SE = 0.056, 95 % CI: 0.001 to 0.215), thereby supporting H6a and H7a. With regard to visit intention, we again find significant indirect effects through entertainment ($B = 0.167$, SE = 0.081, 95 % CI: 0.025 to 0.345) and informativeness ($B = 0.145$, SE = 0.074, 95 % CI: 0.034 to 0.329), which once again leads us to accept H7a and H7b.

4. Discussion

The primary goal of this study was to explore how different modes of interactivity in a VR immersive experience influence an individual's sense of presence within the virtual environment in the context of museums and exhibition visits as well as the psychological mechanisms underlying this effect. Using an experimental design followed by a participant survey, our research contributes to a better understanding of how VR interactivity impacts perceived presence and behavioural intentions.

Findings indicate that incorporating a guide within VR positively influences users' perceived presence, thereby aligning with previous studies that highlight the benefits of guidance in the context of visiting real museums (Hansen and Mossberg, 2016). Additionally, increasing the available movement space for users also enhances perceived presence. This finding is consistent with studies which suggest that real-world movement is perceived as being more natural and realistic (Banakou and Slater, 2023; Chung et al., 2024; Nabiyouni et al., 2015).

This study also delves into how different modes of interaction can affect users' perceived naturalness and physical comfort within the virtual environment, potentially prompting them to seek out or avoid interaction. To explore this, we examined the psychological variables of autonomy and satiation and looked at how interaction modes influence these variables and, in turn, how they impact perceived presence. In line with existing studies (Liu and Tian, 2024), we identify autonomy as an important factor in the creation of presence. While the presence-enhancing effect of the guide is evident, it comes at the cost of a slight reduction in perceived autonomy. These findings are

Table 2
Results of mediation analysis.

	Perceived autonomy			Perceived satiation			Presence		
	β	SE	p	β	SE	p	β	SE	p
Constant	4.987	0.564	0.000	3.472	0.491	0.000	4.460	0.359	0.000
Guidance	−1.780	0.187	0.000	−0.292	0.172	0.090	0.518	0.107	0.000
Spatial mobility	−0.230	0.187	0.218	−0.179	0.175	0.304	0.202	0.099	0.041
Perceived autonomy	-	-	-	-	-	-	0.166	0.037	0.000
Perceived satiety	-	-	-	-	-	-	−0.147	0.047	0.002
Experience VR	−0.149	0.096	0.121	0.033	0.085	0.703	0.042	0.045	0.354
Experience VG	−0.095	0.047	0.043	0.031	0.040	0.427	−0.031	0.025	0.211
Focus Interaction	0.322	0.080	0.000	−0.216	0.068	0.002	0.143	0.050	0.004
R-square	R^2=0.063			R^2=0.394			R^2=0.282		

	Entertainment			Informativeness		
	β	SE	p	β	SE	p
Constant	2.784	0.559	0.000	2.434	0.688	0.000
Presence	0.564	0.086	0.000	0.576	0.108	0.000
R-square	R^2=0.271			R^2=0.206		
	Attitude destination			Visit intention		
	β	SE	p	β	SE	p
Constant	1.084	1.450	0.147	1.056	1.348	0.178
Presence	0.332	2.720	0.007	0.174	1.555	0.120
Entertainment	0.297	2.572	0.010	0.295	2.171	0.030
Informativeness	0.158	1.823	0.068	0.251	2.297	0.022
Knowledge AF	0.057	1.419	0.156	0.094	2.000	0.046
R-square	R^2=0.286			R^2=0.224		

Table 3
Specific and total indirect effects*.

		Effect	*BootCI$_{95\ \%}$*	
			LL	*UL*
	Guidance → Presence	**−0.253**	**−0.415**	**−0.094**
H3a	*Guidance → Autonomy → Presence*	***−0.296***	***−0.450***	***−0.157***
H4a	*Guidance → Satiety → Presence*	*0.043*	*−0.006*	*0.112*
	Spatial mobility → Presence	−0.012	−0.104	0.082
H3b	*Spatial mobility → Autonomy → Presence*	*−0.038*	*−0.114*	*0.019*
H4b	*Spatial mobility → Satiety → Presence*	*0.026*	*−0.022*	*0.094*
	Presence → Attitude destination	**0.258**	**0.142**	**0.398**
H6a	*Presence → Entertainment → Attitude destination*	***0.167***	***0.049***	***0.330***
H7a	*Presence → Informativeness→ Attitude destination*	***0.091***	***0.001***	***0.215***
	Presence → Visit Intention	**0.311**	**0.191**	**0.460**
H6b	*Presence → Entertainment → Visit Intention*	***0.167***	***0.025***	***0.345***
H7b	*Presence → Informativeness→ Visit Intention*	***0.145***	***0.034***	***0.329***

(*) Specific indirect effects are shown in italics.

particularly relevant because, although the positive impact on presence currently outweighs the reduction in autonomy, this balance may shift as users become more experienced with the technology. More skilled or frequent VR users are likely to prefer greater freedom and less guidance, meaning that the trade-off could produce different outcomes depending on user expertise.

Additionally, building on prior research into the potential downsides of immersive technologies such as cybersickness (Hennig-Thurau et al., 2023) and sensory overload (Chen et al., 2023a; Juárez-Varón et al., 2023), we observe that satiation impacts presence, although it does not act as a mediator of the design features considered.

Our study also underscores the role of presence in shaping both user experience with VR and response to the destination: i.e., the museum or exhibition. We find that sense of presence is a strong predictor of attitude towards the destination, both directly and through enhanced experience in terms of entertainment and informational value. This supports previous research that has emphasised the importance of presence in influencing user behaviour (Tussyadiah et al., 2018; Wei et al., 2019).

4.1. Theoretical implications

The current research contributes to the extensive literature on presence in the metaverse (Alyahya and McLean, 2022; Tussyadiah et al., 2018; Wei et al., 2019). Building on common elements in museum contexts, such as guided tours and the physical space available for movement, this study examines how modes of interactivity with VR shape an individual's sense of presence in immersive environments. Furthermore, it enhances our understanding of the mechanisms through which the sense of presence is created. Given the crucial role that this variable plays, understanding how the different ways of interacting with VR can prove influential is key to effectively managing immersive experiences. This study goes beyond previous research, which has mainly focused either on how presence impacts behavioural outcomes or the factors that shape presence itself (Alyahya and McLean, 2022; Bogicevic et al., 2019; Lee et al., 2020b; Tussyadiah et al., 2018; Wei et al., 2019). Since much of the effectiveness of an immersive experience stems from human-environment interaction (Gong et al., 2020; Banakou and Slater, 2023), this study sheds light on how different modes of interaction design can affect perceived presence.

This research also seeks to address the need to understand the psychological and emotional states involved in VR (Dwivedi et al., 2022). In this regard, an approach-avoidance framework (Russell and Mehrabian, 1978) has been applied to explain presence in virtual environments, considering autonomy as a desirable sensation and satiation as an aspect to be avoided. This approach is useful for identifying which types of interaction with VR may enhance users' overall well-being and their sense of presence therein. Findings suggest that the mode of interactivity within the virtual reality can foster or mitigate these sensations and, consequently, the sense of presence, thereby offering a new perspective on individuals' involvement and perception within virtual environments.

The scope of this study extends beyond the mechanisms that shape the creation of presence. It also contributes to the literature on user experience in immersive environments (Cheng et al., 2023b; Flavián et al., 2019) and its impact on behaviour (Tussyadiah et al., 2018). Specifically, we examine the mediating role of user experience in VR vis-à-vis translating presence into attitudinal and behavioural outcomes. Unlike previous studies that assess user experience as a whole, we break this down into its core dimensions –entertainment and informativeness– so as to better understand their distinct effects on attitude and visit intention.

At the same time, this study contributes to the growing body of research on integrating immersive experiences in tourism (Loureiro et al., 2020; Buhalis et al., 2023; Dwivedi et al., 2022), and more specifically in museums (Trunfio et al., 2022; Alabau et al., 2024; Li et al., 2024). It incorporates the study of guidance in immersive experiences –a commonly studied element in traditional museum contexts– in the form of guided tours (Hansen and Mossberg, 2016). Additionally, this work looks at the effect of the available physical space for carrying out the experience in VR –an aspect hitherto not considered.

4.2. Managerial implications

For managers of virtual tourism initiatives such as cultural, artistic, historical, or scientific exhibitions, these results provide valuable guidelines on how to optimize the design of the interaction with immersive experiences so as to maximize users' sense of presence within the virtual environment.

First, given the high level of uncertainty and information overload often associated with interacting in these environments, incorporating guides can help users to feel more present in the immersive experience. Our findings suggest that while this approach may slightly reduce users' sense of autonomy, its benefits outweigh this drawback. Guides not only enhance presence but also positively influence attitude towards the exhibition and the intention to visit it, particularly among users who are not very familiar with immersive technologies. These findings are important for understanding how different forms of interaction with the VR may impact users' overall well-being. Designers of exhibitory proposals in VR should therefore consider incorporating such guides, especially when creating complex experiences or when targeting users who have little technological expertise. It is also important to choose the appropriate guide format to facilitate the visitor's journey. For instance, gamification may prove particularly useful in guiding users through these environments (Flavián et al., 2024). In this regard, the video game industry offers valuable insights into designing guidance systems for VR users. For example, many video games include a guiding companion –such as Jiminy Cricket in the Kingdom Hearts series or Claptrap in Borderlands– whereas others rely on visual cues, like glowing indicators or signs. In World of Warcraft, players are guided by exclamation marks above NPCs, signalling missions that provide experience points.

Second, expanding the available movement space to provide users with greater freedom of movement has a small but positive effect on perceived presence, although it does not translate into changes in individuals' behaviour. This insight suggests that it may be beneficial to allocate slightly larger spaces so that the virtual visitor can experience something closer to the physical experience, where they can walk through the rooms of a museum, exhibition, or a house-museum, as in this study. However, in situations where space is limited or where expanding it would mean drawbacks –such as longer waiting times due to reduced capacity or possible collisions between users– it may be reasonable to forgo additional space and instead implement alternative movement mechanisms such as click-and-teleport controls to enable user mobility without requiring extra physical space.

Finally, this study not only demonstrates how experience design can foster a more positive attitude towards a destination but also how this improved attitude translates into a greater intention to visit. This has practical implications for museum and tourism managers who are considering the use of immersive experiences as promotional tools. Making these experiences available through downloadable content for home VR headsets could allow potential visitors to engage in a "pre-visit," which would ultimately help them to make a final decision concerning whether or not to visit the museum or destination. These findings could be valuable not only in the tourism sector but also in education, research, and cultural outreach. Virtual reality visits offer a way to disseminate art, history, and cultural knowledge remotely, thus enabling broader access to these experiences without the need for physical travel.

4.3. Limitation and future studies

Several limitations are inherent to this study, and which future research could address. First, the sample had limited prior experience with VR technologies. While this may be representative of the general population today, it would be valuable to examine how these findings vary among more experienced users. As consumer familiarity with these technologies increases, certain effects may change. For instance, the reduction in autonomy caused by the guide may outweigh its benefits for presence among highly experienced users, who might see the guide as being unnecessary or even disruptive. Future studies should explore these potential variations in an effort to understand how user expertise moderates the impact of different ways of interacting with virtual reality environments.

Second, although the sample size is substantial, participants were predominantly young university students, which may limit the generalizability of the findings. Future studies should replicate the research with more diverse populations to examine whether the results hold across different user profiles.

Third, the immersive experience in this study lasted 20 min. Future research should investigate the role of satiation in longer immersive experiences, where fatigue and cognitive overload are more likely to occur. Examining how interaction with VR can mitigate these effects in extended sessions would provide a more comprehensive understanding of their potential impact.

Fourth, this study adopts a multidimensional approach to customer experience (Bleier et al., 2018), which typically includes four dimensions: affective, cognitive, sensory, and social. Although the study does analyse entertainment and informativeness, its design did not include sensory and social differences between conditions, since no form of social presence was incorporated and there were no variations in the design or technology that could have produced meaningful sensory differences. This omission limits the extent to which the findings can capture the full richness of a VR museum experience, since the perceived quality of immersion can also stem from embodied sensations or from feeling accompanied within the environment. Results may differ in contexts where sensorial appeal or mediated social presence play a stronger role. For this reason, future research should incorporate these dimensions more explicitly, especially when technological developments (Orús et al., 2021) or interaction design are likely to affect sensory stimulation or socially mediated presence. For instance, comparing visits with multiple participants instead of a single user, or integrating human-to-human and human-NPC interaction such as virtual assistants or service robots acting as guides, could provide a more realistic parallel to traditional museum tours and possibly influence social presence differently.

Finally, future research might compare the results obtained with those of alternative guide formats. In this sense, studies on the application of gamification in virtual environments remain limited (Flavián et al., 2024). Given that games naturally integrate into digital spaces, gamification represents a logical progression in these environments. Gamified tutorials, for instance, could help maintain presence while minimizing perceived loss of autonomy.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used GPT-4o T to assist in identifying and correcting writing errors and to enhance clarity and conciseness. After using this tool, the authors thoroughly reviewed and edited the content, and they take full responsibility for the final published article.

CRediT authorship contribution statement

Elías Vega: Writing – original draft, Methodology, Investigation, Conceptualization. **Carmen Camarero:** Writing – review & editing, Visualization, Supervision, Methodology, Funding acquisition, Formal analysis. **Juho Hamari:** Supervision, Resources, Conceptualization. **Nannan Xi:** Writing – review & editing, Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

Appendix A
Constructs, measures, and correlation matrix.

Constructs and measures	*Mean*	*SD*	*Loadings*
Satiation (adapted from Antón et al., 2018) α:0.801; CR:0.851; AVE:0.703			
The visit felt repetitive.	2.34	1.50	0.849
I ended up feeling overwhelmed after interacting with the metaverse.	2.05	1.45	0.795
After some time interacting with the Anne Frank House in the metaverse, I got bored.	2.13	1.51	0.869
Autonomy (adapted from Liu and Tian, 2024) α:0.860; CR:0.861; AVE:0.877			
I had the freedom to choose which paths to take during the house/museum visit.	5.37	1.78	0.939
I was able to make my own decisions while visiting the house/museum.	5.01	1.87	0.934
Presence (adapted from Alyahya & McLean, 2021) α:0.832; CR:0.833; AVE:0.748			
I felt like I was really there in the VR environment.	6.22	0.91	0.868
It seemed like I was actively participating in the VR action (visiting the Anne Frank House).	6.15	0.89	0.879
It felt like my actual location shifted to the VR environment.	6.04	1.06	0.848
Entertainment (adapted from Bleier et al., 2018) α:0.761; CR:0.763; AVE:0.807			
I found the house/museum tour presentation entertaining.	6.23	1.01	0.906
My experience visiting the house/museum in the metaverse was fun.	6.26	0.98	0.891
Informativeness (adapted from Bleier et al., 2018) α:0.789; CR:0.792; AVE:0.826			
The way the information was presented allowed me to learn a lot about the Anne Frank House.	5.96	1.11	0.915
The information obtained during the virtual visit was useful.	5.99	1.19	0.902
Attitude towards destination (adapted from Alyahya & McLean, 2021) α:0.865; CR:0.866; AVE:0.881			
After the virtual tour, I consider the Anne Frank House-Museum as a tourist destination to be (bad/good)	6.10	1.22	0.935
After the virtual visit, my attitude towards the Anne Frank House Museum as a tourist destination is (unfavourable/favourable)	6.13	1.09	0.942
Visit Intention (adapted from Alyahya & McLean, 2021) α:0.839; CR:0.875; AVE:0.751			
I would visit the destination in the future.	6.01	1.19	0.865
I could see myself visiting the destination in the future.	5.73	1.44	0.883
It is likely that I will visit the destination in the future.	5.65	1.48	0.849
Control variables			
Knowledge AF: Level of knowledge about Anne Frank's history.	3.48	1.55	-
Experience VR: Level of experience with virtual reality headsets.	1.77	1.20	-
Experience VG: Level of experience playing video games.	4.11	2.14	-
Focus interaction: I was focused on the interactive elements and clues provided by the story.	6.21	0.97	-

(α = Cronbach's Alpha, CR= Composite Reliability, AVE=Average Variance Extracted.

Appendix B
Discriminant validity of the scales.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
(1) Guidance	**n.a.**	0.005	0.589	0.130	0.130	0.028	0.199	0.229	0.126	0.055	0.065	0.090	0.141
(2) Spatial mobility	−0.005	**n.a.**	0.098	0.053	0.074	0.115	0.047	0.091	0.045	0.060	0.057	0.102	0.054
(3) Perceived autonomy	−0.547	−0.092	**0.937**	0.050	0.291	0.289	0.156	0.090	0.113	0.109	0.206	0.314	0.117
(4) Perceived satiety	−0.121	−0.056	−0.036	**0.838**	0.390	0.468	0.359	0.344	0.262	0.066	0.065	0.223	0.081
(5) Presence	0.118	0.066	0.246	−0.339	**0.865**	0.654	0.566	0.527	0.406	0.066	0.126	0.361	0.067
(6) Entertainment	0.022	0.101	0.234	−0.383	0.522	**0.898**	0.599	0.550	0.497	0.070	0.100	0.519	0.041
(7) Informativeness	0.175	0.030	0.129	−0.316	0.460	0.465	**0.909**	0.464	0.478	0.041	0.097	0.404	0.011
(8) Attitude	0.213	0.083	0.076	−0.321	0.447	0.447	0.384	**0.939**	0.865	0.029	0.162	0.315	0.068
(9 Visit intention	0.133	0.040	0.096	−0.255	0.362	0.418	0.410	0.771	**0.866**	0.159	0.190	0.390	0.119
(10) Experience VR	−0.055	−0.060	−0.100	0.066	−0.035	−0.061	−0.016	−0.027	−0.141	**n.a.**	0.305	0.028	0.103
(11) Experience VG	0.065	0.057	−0.191	0.064	−0.116	−0.090	−0.085	−0.151	−0.184	0.305	**n.a.**	0.014	0.039
(12) Focus interaction	−0.090	−0.102	0.290	−0.205	0.329	0.453	0.357	0.293	0.356	0.028	−0.014	**n.a.**	0.013
(13) Knowledge AF	−0.141	0.054	0.109	0.074	−0.061	−0.008	−0.005	0.064	0.101	−0.103	−0.039	0.013	**n.a.**

n.a. = Not applicable. The diagonal elements (in bold) are the square roots of the AVEs. Above the diagonal elements are the HTMT values. Values below the diagonal elements are the inter-construct correlations.

Appendix A, B

Data availability

Data will be made available on request.

References

Alabau, A., Fabra, L., Martí-Testón, A., Muñoz, A., Solanes, J.E., Gracia, L., 2024. Enriching user-visitor experiences in digital museology: combining social and virtual interaction within a metaverse environment. Appl. Sci. 14 (9), 3769. https://doi.org/10.3390/app14093769.

Alyahya, M., McLean, G., 2022. Examining tourism consumers' attitudes and the role of sensory information in virtual reality experiences of a tourist destination. J. Travel Res. 61 (7), 1666–1681. https://doi.org/10.1177/00472875211037745.

Antón, C., Camarero, C., Garrido, M.J., 2018b. A journey through the museum: visit factors that prevent or further visitor satiation. Ann. Tour. Res. 73, 48–61. https://doi.org/10.1016/j.annals.2018.08.002.

Antón, C., Camarero, C., Laguna-García, M., 2018a. Experience value or satiety? The effects of the amount and variety of tourists' activities on perceived experience. J. Travel Res. 57 (7), 920–935.

Arnold, M.J., Reynolds, K.E., 2012. Approach and avoidance motivation: investigating hedonic consumption in a retail setting. J. Retail. 88 (3), 399–411. https://doi.org/10.1016/j.jretai.2011.12.004.

Banakou, D., Slater, M., 2023. A comparison of two methods for moving through a virtual environment: walking in place and interactive redirected walking. Front. Virtual Real. 4, 1294539. https://doi.org/10.3389/frvir.2023.1294539.

Bleier, A., Harmeling, C.M., Palmatier, R.W., 2018. Creating effective online customer experiences. J. Mark. 83 (2), 98–119. https://doi.org/10.1177/0022242918809930.

Bogicevic, V., Seo, S., Kandampully, J.A., Liu, S.Q., Rudd, N.A., 2019. Virtual reality presence as a preamble of tourism experience: the role of mental imagery. Tour. Manag. 74, 55–64. https://doi.org/10.1016/j.tourman.2019.02.009.

Buhalis, D., 2020. Technology in tourism-from information communication technologies to eTourism and smart tourism towards ambient intelligence tourism: a perspective article. Tour. Rev. 75, 267–272. https://doi.org/10.1108/TR-06-2019-0258.

Buhalis, D., Karatay, N., 2022. Mixed reality (MR) for generation Z in cultural heritage tourism towards metaverse. *Information and communication technologies in tourism 2022*. In: Proceedings of the ENTER 2022 eTourism conference. Springer, Cham, pp. 16–27. https://doi.org/10.1007/978-3-030-94751-4_2.

Buhalis, D., Leung, D., Lin, M., 2023. Metaverse as a disruptive technology revolutionising tourism management and marketing. Tour. Manag. 97. https://doi.org/10.1016/j.tourman.2023.104724.

Calisto, M., de, L., Sarkar, S., 2024. A systematic review of virtual reality in tourism and hospitality: the known and the paths to follow. Int. J. Hosp. Manage 116, 103623. https://doi.org/10.1016/j.ijhm.2023.103623.

Chen, J., Xi, N., Pohjonen, V., Hamari, J., 2023a. Paying attention in metaverse: an experiment on spatial attention allocation in extended reality shopping. Inf. Technol. People 36 (8), 255–283. https://doi.org/10.1108/ITP-09-2021-0674.

Cheng, A., Ma, D., Pan, Y., Qian, H., 2023b. Enhancing museum visiting experience: investigating the relationships between augmented reality quality, immersion, and TAM using PLS-SEM. Int. J. Hum.–Comput. Interact. 40 (17), 4521–4532. https://doi.org/10.1080/10447318.2023.2227832.

Cherep, L.A., Lim, A.F., Kelly, J.W., Acharya, D., Velasco, A., Bustamante, E., Ostrander, A.G., Gilbert, S.B., 2020. Spatial cognitive implications of teleporting through virtual environments. J. Exp. Psychol.: Appl. 26 (3), 480–492. https://doi.org/10.1037/xap0000263.

Chung, S.J., Kim, S.Y., Kim, K.H., 2024. Comparison of visitor experiences of virtual reality exhibitions by spatial environment. Int J Hum Comput Stud 181, 103145. https://doi.org/10.1016/j.ijhcs.2023.103145.

Clark, W.R., Ezell, J., Clark, J., Sheffield, D.N., 2009. Stay or leave: applying approach–avoidance theory to virtual environments. J. Database Mark. Cust. Strategy Manag. 16, 231–240.

Cummings, J.J., Bailenson, J.N., 2015. How immersive is enough? A meta-analysis of the effect of immersive technology on user presence. Media Psychol. 19 (2), 272–309. https://doi.org/10.1080/15213269.2015.1015740.

Cuny, C., Fornerino, M., Helme-Guizon, A., 2015. Can music improve e-behavioral intentions by enhancing consumers' immersion and experience? Inf. Manag. 52 (8), 1025–1034. https://doi.org/10.1016/j.im.2015.07.009.

Di Dalmazi, M., Mandolfo, M., Guixeres, J., Alcañiz Raya, M., Lamberti, L., 2024. How immersive technologies impact behavioral responses in destination marketing: the role of physiological arousal, presence, and age. Int. J. Contemp. Hosp. Manag. 36 (11), 3628–3650. https://doi.org/10.1108/IJCHM-09-2023-1511.

Dwivedi, Y.K., Hughes, L., Baabdullah, A.M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M.M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C.M.K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D.P., Gustafsson, A., Hinsch, C., Jebabli, I., Janssen, M., Wamba, S.F., 2022. Metaverse beyond the hype: multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. Int. J. Inf. Manage 66, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542.

Fan, X., Jiang, X., Deng, N., 2022. Immersive technology: a meta-analysis of augmented/virtual reality applications and their impact on tourism experience. *Tourism Management, 91*, 104534. https://doi.org/10.1016/j.tourman.2022.104534.

Flavián, C., Ibáñez-Sánchez, S., Orús, C., 2019. The impact of virtual, augmented and mixed reality technologies on the customer experience. J. Bus. Res. 100, 547–560. https://doi.org/10.1016/j.jbusres.2018.10.050.

Flavián, C., Ibáñez-Sánchez, S., Orús, C., Barta, S., 2024. The dark side of the metaverse: the role of gamification in event virtualization. Int. J. Inf. Manage 75, 102726. https://doi.org/10.1016/j.ijinfomgt.2023.102726.

Gavgani, A.M., Walker, F.R., Hodgson, D.M., Nalivaiko, E., 2018. A comparative study of cybersickness during exposure to virtual reality and "classic" motion sickness: are they different? J. Appl. Physiol. 125 (6), 1670–1680. https://doi.org/10.1152/japplphysiol.00338.2018.

Gong, L., Söderlund, H., Bogojevic, L., Chen, X., Berce, A., Fast-Berglund, Å., Johansson, B., 2020. Interaction design for multi-user virtual reality systems: an automotive case study. Procedia CIRP. 93, 1259–1264. https://doi.org/10.1016/j.procir.2020.04.036.

Han, D.I.D., Melissen, F., Haggis-Burridge, M., 2023. Immersive experience framework: a Delphi approach. Behav Inf Technol 43 (4), 623–639. https://doi.org/10.1080/0144929X.2023.2183054.

Han, D.I., tom Dieck, M.C., Jung, T., 2017. User experience model for augmented reality applications in urban heritage tourism. J. Herit. Tour. 13 (1), 46–61. https://doi.org/10.1080/1743873X.2016.1251931.

Hansen, A.H., Mossberg, L., 2016. Tour guides' performance and tourists' immersion: facilitating consumer immersion by performing a guide plus role. Scand. J. Hosp. Tour. 17 (3), 259–278. https://doi.org/10.1080/15022250.2016.1162347.

Hayes, A.F., 2017. Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach. Guilford Press, New York.

Hennig-Thurau, T., Aliman, D.N., Herting, A.M., et al., 2023. Social interactions in the metaverse: framework, initial evidence, and research roadmap. J. Acad. Mark. Sci. 51 (4), 889–913. https://doi.org/10.1007/s11747-022-00908-0.

Holloway, C., 1981. The guided tour: a sociological approach. Ann. Tour. Res. 8, 377–402. https://doi.org/10.1016/0160-7383(81)90005-0.

Hudson, S., Matson-Barkat, S., Pallamin, N., Jegou, G., 2019. With or without you? Interaction and immersion in a virtual reality experience. J. Bus. Res. 100, 459–468. https://doi.org/10.1016/j.jbusres.2018.10.062.

Ibáñez-Sánchez, S., Orús, C., Flavián, C., 2022. Augmented reality filters on social media. Analyzing the drivers of playability based on uses and gratifications theory. Psychol. Mark. 39, 559–578. https://doi.org/10.1002/mar.21639.

Jaud, D.A., Braconnot, A.R., Lunardo, R., 2023. The boundary effects of matching package type and product dimension. J. Consum. Behav. 22 (5), 1224–1236. https://doi.org/10.1002/cb.2207.

Jeong, J.-H., Lee, K.-H., 2006. The physical environment in museums and its effects on visitors' satisfaction. Build Env. 41 (7), 963–969. https://doi.org/10.1016/j.buildenv.2005.04.004.

Juárez-Varón, D., Mengual-Recuerda, A., Capatina, A., Núñez Cansado, M., 2023. Footwear consumer behavior: the influence of stimuli on emotions and decision making. J. Bus. Res. 164, 114016. https://doi.org/10.1016/j.jbusres.2023.114016.

Ketron, S., Cowan, K., 2025. Presenting a typology of virtual reality (VR) in retailing: a construal level theory and heuristic-systematic model perspective. J. Retail. https://doi.org/10.1016/j.jretai.2025.06.005.

Kim, S., Chen, R.P., Zhang, K., 2016. Anthropomorphized helpers undermine autonomy and enjoyment in computer games. J. Consum. Res. 43 (2), 282–302. https://doi.org/10.1093/jcr/ucw016.

Kostyk, A., Cowan, K., Dessart, L., Schyns, M., 2024. Memories of tourism brands in virtual reality. Ann. Tour. Res. 109, 103824. https://doi.org/10.1016/j.annals.2024.103824.

Laine, T.H., Lee, W., Moon, J., Kim, E., 2025. Building confidence in the metaverse: implementation and evaluation of a multi-user virtual reality application for overcoming fear of public speaking. Int. J. Hum. Comput. Stud. 199, 103487. https://doi.org/10.1016/j.ijhcs.2025.103487.

Lee, E.A.-L., Wong, K.W., Fung, C.C., 2010. How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. Comput. Educ. 55 (4), 1424–1442. https://doi.org/10.1016/j.compedu.2010.06.006.

Lee, H., Jung, T.H., tom Dieck, M.C., Chung, N., 2020a. Experiencing immersive virtual reality in museums. Inf. Manag. 57 (5), 103229. https://doi.org/10.1016/j.im.2019.103229.

Lee, K.M., 2004. Presence, explicated. Commun. Theory 14, 27–50. https://doi.org/10.1111/j.1468-2885.2004.tb00302.x.

Lee, M., Lee, S.A., Jeong, M., Oh, H., 2020b. Quality of virtual reality and its impacts on behavioral intention. Int. J. Hosp. Manage 90, 102595. https://doi.org/10.1016/j.ijhm.2020.102595.

Lemon, K.N., Verhoef, P.C., 2016. Understanding customer experience throughout the customer journey. J. Mark. 80 (6), 69–96. https://doi.org/10.1509/jm.15.0420. Original work published 2016.

Li, M., Sun, X., Zhu, Y., Qiu, H., 2024. Real in virtual: the influence mechanism of virtual reality on tourists' perceptions of presence and authenticity in museum tourism. Int. J. Contemp. Hosp. Manag. 36 (11), 3651–3673.

Liu, G., Tian, B., 2024. Investigating the impact of autonomy on presence: a comparative analysis on sense of presence and telepresence. Inf. Technol. Tour. 26, 347–367. https://doi.org/10.1007/s40558-024-00285-0.

Loureiro, S.C., Guerreiro, J., Ali, F., 2020. 20 years of research on virtual reality and augmented reality in tourism context: a text-mining approach. Tour. Manag. 77. https://doi.org/10.1016/j.tourman.2019.104028.

Lu, A., Baranowski, T., Thompson, D., Buday, R., 2012. Story immersion of videogames for youth health promotion: a review of literature. Games Health J.: Res. Dev. Clin. Appl. 1 (3), 199–204. https://doi.org/10.1089/g4h.2011.0012.

Martínez-Molés, V., Jung, T.H., Pérez-Cabañero, C., Cervera-Taulet, A., 2022. Gathering pre-purchase information for a cruise vacation with virtual reality: the effects of media technology and gender. Int. J. Contemp. Hosp. Manag. 34 (1), 407–429. https://doi.org/10.1108/IJCHM-04-2021-0500.

McAlister, L., 1982. A dynamic attribute satiation model of variety-seeking behavior. J. Consum. Res. 9 (2), 141–150. https://doi.org/10.1086/208907.
McLean, G., AlYahya, M., Barhorst, J.B., Osei-Frimpong, K., 2023. Examining the influence of virtual reality tourism on consumers' subjective wellbeing. Tour. Manag. Perspect. 46, 101088.
Nabiyouni, M., Saktheeswaran, A., Bowman, D.A., 2015. Comparing the performance of natural, semi-natural, and non-natural locomotion techniques in virtual reality. In: 3D User Interfaces (3DUI), 2015 IEEE Symposium on. IEEE. https://doi.org/10.1109/3DUI.2015.7131717.
Nelson, N.M., Redden, J.P, 2017. Remembering satiation: the role of working memory in satiation. J. Consum. Res. 44 (3), 633–650. https://doi.org/10.1093/jcr/ucx056.
Orús, C., Ibáñez-Sánchez, S., Flavián, C., 2021. Enhancing the customer experience with virtual and augmented reality: the impact of content and device type. Int. J. Hosp. Manage 98, 103019. https://doi.org/10.1016/j.ijhm.2021.103019.
Peterson, R.A., Merunka, D., 2014. Convenience samples of college students and research reproducibility. J. Bus. Res. 67 (5), 1035–1041. https://doi.org/10.1016/j.jbusres.2013.08.010. No.
Prithul, A., Adhanom, I.B., Folmer, E., 2021. Teleportation in virtual reality: a mini-review. Front. Virtual Real. 2, 730792. https://doi.org/10.3389/frvir.2021.730792.
Puig, A., Rodríguez, I., Arcos, J.L., Rodríguez-Aguilar, J.A., Cebrián, S., Bogdanovych, A., Piqué, R., 2020. Lessons learned from supplementing archaeological museum exhibitions with virtual reality. Virtual. Real. 24 (2), 343–358.
Rauschnabel, P.A., Felix, R., Hinsch, C., Shahab, H., Alt, F., 2022. What is XR? Towards a framework for augmented and Virtual reality. Comput Hum. Behav 133. https://doi.org/10.1016/j.chb.2022.107289.
Richardson, J., 2024. Virtual reality is a big trend in museums, but what are the best examples of museums using VR? MuseumNext. Retrieved March 2025, from. https://www.museumnext.com/article/how-museums-are-using-virtual-reality/.
Riva, G., 2022. Virtual reality in clinical psychology. Comprehensive Clinical Psychology, 2nd ed. Elsevier, pp. 91–105. https://doi.org/10.1016/B978-0-12-818697-8.00006-6.
Rusell, J.A., Mehrabian, A., 1978. Approach avoidance and affiliation as functions of the emotion-eliciting quality of an environment. Env. Behav. 10 (3), 355–387.
Ryan, R.M., Deci, E.L., 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am. Psychol. 55 (1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68.
Sánchez-Amboage, E., Enrique Membiela-Pollán, M., Martínez-Fernández, V.A., Molinillo, S., 2023. Tourism marketing in a metaverse context: the new reality of European museums on meta. Mus. Manag. Curatorsh. 38 (4), 468–489.
Shahab, H., Mohtar, M., Ghazali, E., Rauschnabel, P.A., Geipel, A., 2023. Virtual reality in museums: does it promote visitor enjoyment and learning? Int. J. Hum.–Comput. Interact. 39 (18), 3586–3603.
Silva, J.H.O., Mendes, G.H.S., Cauchick Miguel, P.A., Amorim, M., Teixeira, J.G., 2021. Customer experience research: intellectual structure and future research opportunities. J. Serv. Theory Pract. 31 (6), 893–931. https://doi.org/10.1108/JSTP-08-2020-0193.
Slater, M., Steed, A., 2000. A virtual presence counter. Presence: Teleoperators Virtual Environ. 9 (5), 413–434. https://doi.org/10.1162/105474600566925.
Stracke, C.M., Bothe, P., Adler, S., 2025. Immersive virtual reality in higher education: a systematic review of the scientific literature. Virtual. Real. 29, 64. https://doi.org/10.1007/s10055-025-01136-x.
Sylaiou, S., Mania, K., Karoulis, A., White, M., 2010. Exploring the relationship between presence and enjoyment in a virtual museum. Int J Hum Comput Stud 68 (5), 243–253. https://doi.org/10.1016/j.ijhcs.2009.11.002.
tom Dieck, M.C., Jung, T.H., tom Dieck, D., 2016. Enhancing art gallery visitors' learning experience using wearable augmented reality: generic learning outcomes perspective. Curr. Issues Tour. 21 (17), 2014–2034. https://doi.org/10.1080/13683500.2016.1224818.
Trunfio, M., Lucia, M.D., Campana, S., Magnelli, A., 2022. Innovating the cultural heritage museum service model through virtual reality and augmented reality: the effects on the overall visitor experience and satisfaction. J. Herit. Tour. 17 (1), 1–19.
Tussyadiah, I.P., Wang, D., Jung, T.H., tom Dieck, M.C., 2018. Virtual reality, presence, and attitude change: empirical evidence from tourism. Tour. Manag. 66, 140–154. https://doi.org/10.1016/j.tourman.2017.12.003.
Uysal, E., Finken, D., Krämer, M., Alavi, S., Jun, Y., Schendzielarz, D., 2025. Virtually mine: understanding consumer responses to virtual reality product presentations. J. Retail. https://doi.org/10.1016/j.jretai.2025.04.007.
Walbank, J., 20 January 2023. Mob.-Mag., Obtained Top 10 co. invest. metaverse 2023. https://mobile-magazine.com/articles/top-10-companies-investing-in-the-metaverse-in-2023.
Wang, D., Peng, Y., Haddouk, L., Vayatis, N., Vidal, P.-P., 2025. Assessing virtual reality presence through physiological measures: a comprehensive review. Front. Virtual Real. 6. https://doi.org/10.3389/frvir.2025.1530770.
Wang, Y., Liu, W., Yu, X., Li, B., Wang, Q., 2024. The impact of virtual technology on students' creativity: a meta-analysis. Comput. Educ. 215, 105044. https://doi.org/10.1016/j.compedu.2024.105044.
Weech, S., Kenny, S., Lenizky, M., Barnett-Cowan, M., 2020. Narrative and gaming experience interact to affect presence and cybersickness in virtual reality. Int. J. Hum. Comput. Stud 138, 102398. https://doi.org/10.1016/j.ijhcs.2020.102398.
Wei, W., Qi, R., Zhang, L., 2019. Effects of virtual reality on theme park visitors' experience and behaviors: a presence perspective. Tour. Manag. 71, 282–293. https://doi.org/10.1016/j.tourman.2018.10.024.
Wiepke, A., Heinemann, B., 2024. A systematic literature review on user factors to support the sense of presence in virtual reality learning environments. Comput. Educ.: X Real. 4, 100064. https://doi.org/10.1016/j.cexr.2024.100064.
World Economic Forum, 2022. How the Metaverse Can Be a Force for Good in an Uncertain World. Retrieved from. https://www.weforum.org/agenda/2022/05/how-metaverse-can-be-a-force-for-good-in-an-uncertain-world/.
Xi, N., Hamari, J., 2020. Does gamification affect brand engagement and equity? A study in online brand communities J. Bus. Res. 109, 449–460. https://doi.org/10.1016/j.jbusres.2019.11.058.
Xi, N., Hamari, J., 2021. Shopping in virtual reality: a literature review and future agenda. J. Bus. Res. 134, 37–58. https://doi.org/10.1016/j.jbusres.2021.04.075.
Ying, T., Tang, J., Ye, S., Tan, X., Wei, W., 2021. Virtual reality in destination marketing: telepresence, social presence, and tourists' visit intentions. J. Travel Res. 61 (8), 1738–1756. https://doi.org/10.1177/00472875211047273.
Yu, H., Oh, H., Wang, K.C., 2024. Virtual reality and perceptions of destination presence. Int. J. Contemp. Hosp. Manag. 36 (11), 3950–3968.
Yung, R., Khoo-Lattimore, C., Potter, L.E., 2020. Virtual reality and tourism marketing: conceptualizing a framework on presence, emotion, and intention. Curr. Issues Tour. https://doi.org/10.1080/13683500.2020.1820454.
Zhu, C., Hall, C.M., Fong, L.H.N., Liu, C.Y.N., Koupaei, S.N., 2024a. Vividness, narrative transportation, and sense of presence in destination marketing: empirical evidence from augmented reality tourism. Asia Pac. J. Tour. Res. 1–13. https://doi.org/10.1080/10941665.2024.2383218.
Zhu, C., Wu, D.C.W., Lu, Y., Fong, L.H.N., She, L.S., 2024b. When virtual reality meets destination marketing: the mediating role of presences between vividness and user responses. J. Vacat. Mark. 30 (3), 408–422. https://doi.org/10.1177/13567667221141414.