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ORIGINAL RESEARCH

A user experience perspective on heritage tourism in the metaverse: Empirical evidence and design dilemmas for VR

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Abstract

The tourism industry will be shaped by the growth and development of the metaverse in the coming decades. Virtual reality (VR) will enable the creation of virtual worlds, avatars, digital twins, and new social networks. These technologies can be utilized in tourism to enable travelers to preview real-world experiences, to enhance experiences while on-site, to relive experiences after travel, or in some cases to even substitute for travel. Given the metaverse's transformative potential, empirical investigation of VR is clearly warranted. Studies of VR tourism typically choose a single specific VR application and investigate its impact on adoption or user satisfaction. This application-level focus is a significant limitation. We therefore evaluate multiple heritage tourism applications as well as VR hardware in a comprehensive and structured analysis from the user experience (UX) perspective. Our content analysis of user interviews reveals 13 factors that shape users' overall perceptions about VR. These factors are grouped into categories related to presentation of the VR content, the content itself, and the functionality of the hardware and software. Our analysis also reveals three design dilemmas for creators of VR heritage tourism content for the metaverse. Implications and an agenda for future research are included.

Keywords Virtual Reality (VR) · Metaverse · User experience · Heritage tourism · Interview

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1 Introduction

Technology has and will continue to disrupt operational practices for business the world over (Buhalis et al. 2023; Gursoy et al. 2022). In the virtual reality (VR) space, this will proceed as the metaverse attracts more interest and investment. The metaverse refers to a 3D virtual shared world where all activities can be carried out with the help of augmented and virtual reality services (Damar 2021, p. 1). It is " a shared online space that incorporates three-dimensional graphics, either on a screen or in virtual reality" (Sparkes 2021, p. 18). In tourism, the metaverse is seen as a platform through which greater experiences can be offered to travelers before, during, and after their travels, while also facilitating interactions in the virtual world (Buhalis et al. 2023; Dwivedi et al. 2022; Koo et al. 2022).

While the development of the metaverse is in its early stages, supporting technologies such as VR apps and VR headsets (formally known as HMDs, head-mounted devices), are becoming more common. Recent statistics suggest that the VR market is worth US$6 billion and is anticipated to grow at a compound annual growth rate of 25% over the next 10 years (GlobalData 2022). The number of HMDs is estimated to grow from around 20 million units in 2020 to over 60 million by 2026 (The Economist 2022). There has been a 14% increase in the number of VR start-ups in less than one year, with 75% of Forbes' "Most Valuable Brands" using either VR or AR (Blagojević 2023). By 2030, VR is anticipated to influence over 20 million jobs and contribute US$1.9 trillion to the global economy (Blagojević 2023). These statistics point towards rapid growth and adoption of VR technology throughout business and society in industries as diverse as healthcare, education, defense, entertainment, logistics, manufacturing, and tourism (Blagojević 2023).

In tourism, VR complements travel by supporting users' travel planning (Guttentag 2010) and facilitating access to hard-to-reach or environmentally sensitive destinations (Egger 2016; W. Lee and Kim 2021). Travelers may plan to use the metaverse and its associated VR systems to replace, complement, or enhance their experiences (Egger 2016; Guttentag 2010; W. Lee and Kim 2021). In light of these trends, it is important to examine how users will react to and adopt metaverse technologies.

When examining technologies, the user experience (UX) perspective has been used to describe users' "perception and responses that result from the use or anticipated use of a product, system or service" (Law et al. 2009, p. 179). UX takes into consideration the user's internal state, the system, and the context in which the system is being used to understand users' attitudes towards a system (Hassenzahl and Tractinsky 2006). It is vital for businesses and software developers to understand the nuances of users' experiences to gain insight into customer loyalty (Garrett 2010), satisfaction, and positive word of mouth (Han et al. 2018); thus, the UX perspective is extremely valuable.

Despite the value and importance of understanding user experiences in the development and implementation of metaverse technologies, there is scant

theoretical and empirical research on the topic (Han et al. 2018). This paper, therefore, sets out to understand users' experiences of contemporary metaverse technologies. Specifically, we interview users of VR HMDs and their associated apps to offer insights to metaverse researchers and developers. By having participants wear the headset, try the virtual interface, and experience multiple apps, it was possible to interview participants and gain rich insights about the potential of the metaverse. TV and computer video, both of which are still far more widely used than VR, are also discussed as a point of comparison. Analysis reveals what considerations and trade-offs need to be made in creating metaverse heritage tourism content for consumers. This is therefore, the first study to offer such insight and comparison into the potential user experience of the metaverse.

The paper proceeds as follows. In Sect. 2, we first review literature on the metaverse, an important emerging technological phenomenon in tourism. We then review literature on VR, one of the key technologies of the metaverse, identifying areas for extension of prior work. We also review literature on the User Experience (UX) approach to technology design and highlight how it can complement existing research to provide new insights. In Sect. 3, we describe our methodological approach, including data collection through structured interviews with users of VR head-mounted devices (HMDs) and multiple heritage tourism applications. This study is one of the first to empirically test features of the metaverse by having participants experience a selection of VR apps while using a fully-immersive VR HMD. Section 4 presents analysis of the interview data, where we describe the key findings of our study, organizing them around the UX categories of presentation, content, and functionality (Han et al. 2018; Hassenzahl 2003). The primary contribution of this study is the evaluation framework of VR apps in tourism and the empirically derived factors affecting the user experience. An important secondary contribution appears in Sect. 5, where we discuss our findings. Since the analysis was conducted using popular VR apps and a state-of-the-art HMD, detailed design implications are presented. These implications are framed as three dilemmas for researchers and practitioners to consider as they develop new content for VR tourism experiences for the metaverse. Limitations of this study and directions for future research are included as well.

2 Literature review

2.1 Metaverse tourism

The metaverse is a term coined by Neal Stephenson in his novel *Snow Crash* (1992). The term is a portmanteau of "meta", which means "beyond" in Greek and "universe". Thus, the metaverse is a "universe beyond" the physical one. In Stephenson's original vision, it is an immersive virtual world that exists in parallel to the physical world – a digital twin of the real world. Since the origination of the term, it has been defined as "a shared online space that incorporates three-dimensional graphics, either on a screen or in virtual reality" (Sparkes 2021, p. 18), where all activities can be carried out with the help of augmented and virtual reality (Damar 2021, p. 1). It

is an "all-encompassing virtual world that exists in parallel to the physical world of the real world" (Buhalis et al. 2023, p. 3) and a seamless convergence of digital and physical universes that use ambient intelligence to enhance physical spaces, products and services (Buhalis and Karatay 2022).

Early instances of virtual worlds such as Second Life, as well as more recent ones such as Roblox and Fortnite, are highlighted as examples of the metaverse (or as metaverses). The OASIS immersive virtual universe in Steven Spielberg's film *Ready Player One* is also frequently mentioned as an example (Buhalis et al. 2023). Some technology leaders see the metaverse as a revolutionary technology. The most notable is Mark Zuckerberg who has referred to the Metaverse as "the next chapter for the Internet" (Zuckerberg 2021) and believes so strongly in its transformative potential that he has re-named his company Meta (previously Facebook). Virtual communities with social networking and avatars are features in some instantiations of the metaverse.

Tourism is one area in which the metaverse and related technologies are poised to have a meaningful impact. Tourists can use technologies such as VR HMDs to visit digital twins of tourism attractions either prior to travel to preview an experience, during travel to enhance an experience, or afterward to relive an experience (Buhalis et al. 2023; Nam et al. 2022). Augmented reality (AR) and mixed reality (MR) can be used on-site to provide additional information about attractions. Metaverse technologies can reduce anxiety for travelers (Buhalis et al. 2023). Metaverse technologies may even be able to serve as a substitute for travel, such as during the COVID-19 pandemic when borders were closed. Similarly, when attractions are closed for renovations (such as the long-delayed Grand Egyptian Museum), unreachable because of unrest (Peru in early 2023, or Syria and Yemen during their civil wars), environmentally sensitive (such as Antarctica) or otherwise inaccessible, metaverse technologies such as VR can provide a substitute. Additionally, for would-be travelers with mobility impairments or other health issues, metaverse travel experiences may be an acceptable substitute (Rubio-Escuderos et al. 2021).

Scholarly research on the metaverse is in a very early phase. Key technologies in the metaverse have been identified as the Internet, VR, AR, the Internet of Things (IoT), 5G mobile communication, and online virtual worlds, with applications of these technologies seen in e-learning, healthcare, gaming, entertainment, retailing, and product design (Trunfio and Rossi 2022). Some have conducted literature reviews, presented propositions for future study, and developed models of the metaverse ecosystem (Koo et al. 2022; Polyviou and Pappas 2022), with others presenting research agendas (Dwivedi et al. 2022; Trunfio and Rossi 2022).

Researchers have observed that the metaverse may usher in new ways for businesses to interact with customers, will require new skills for customers and employees, will alter business processes, and will introduce the need for new regulation (Polyviou and Pappas 2022). Nevertheless, we observe that this existing work is limited because it is largely conceptual in nature, with only models, frameworks, and propositions presented. Empirical research into the metaverse is scant.

The one area where empirical work does exist, however, is virtual reality (VR). VR is arguably the central technology of the metaverse, enabling sensorially rich online interactions in digitally-created worlds. Significant investments have been

made in VR by hardware manufacturers such as Meta, Oculus, Sony, HTC, Samsung, and others. Content creators have also invested considerable resources in VR and have developed not only games, but tourism experiences such as those from National Geographic and e-commerce experiences such as those from Gucci and Ralph Lauren. Therefore, given the more mature state and the existence of empirical findings, it is to the topic of VR that we now turn.

2.2 Virtual reality

Virtual Reality (VR) is a "computer-generated three-dimensional environment that one can navigate and possibly interact with, resulting in real-time stimulation of one or more of the user's five senses" (Guttentag 2010). The VR medium should enable users to feel that they have been transported from the physical world to a simulated one (Hobson and Williams 1995). Users may even sense that they are present in another location – either another real-world location or a synthetic, computer-generated location (Desai et al. 2014).

Instantiations of VR can be categorized into three subtypes: as either non-immersive VR, semi-immersive VR, or fully-immersive VR (Beck et al. 2019). The degree of immersiveness, which enables this categorization, addresses the degree to which the VR experience isolates the user from the real, physical world.

2.2.1 Non-immersive VR (niVR)

Non-immersive VR (niVR) "displays synthetic or 360-degree real-life captured content on a conventional (computer) screen, enabling virtual touristic experiences that stimulate the visual sense and potentially other senses of the user…often presented to the user on a desktop, laptop, or smartphone…" (Beck et al. 2019, p. 592). Given that the user is viewing this VR experience on a desktop, laptop, or smartphone, he or she is still generally quite aware of the real-world environment, possibly including other objects such as tables, chairs, or desks, other individuals, ambient noise, and possibly other characteristics of their space. The user is not isolated from the real world to a great degree; hence the description of this type as non-immersive VR. Common uses of niVR include 360-degree walkthroughs of buildings, such as for real estate sales, for hotels, and for web-based virtual tours (O. Lee and Ahn 2012; Wan et al. 2007). Second Life, as it exists on PCs and laptops, is also an example of niVR (Huang et al. 2013).

Research on niVR has demonstrated the effectiveness of VR in comparison to traditional brochures (Chiou et al. 2008; Hyun and O'Keefe 2012; Wan et al. 2007). Perhaps unsurprisingly, niVR contributes to a sense of presence; that is, that a user is present in another location. Offline information, such as that provided in brochures does not create a similar sense of presence (O. Lee and Ahn 2012). Additionally, other researchers have shown that presence, users' perceived level of skill, and the interactivity of the niVR experience all contribute to a sense of flow and increased intention to travel (Huang et al. 2012). In more recent research, system quality was

shown to positively influence authenticity and presence, both of which in turn influence satisfaction with the VR experience (Nam et al. 2022).

Theories used in niVR research include the technology acceptance model (TAM), where perceived ease of use and perceived usefulness enhance flow, emotional involvement, and positive emotions to contribute to intention to visit (Huang et al. 2013). Self-determination theory has also been used to undergird niVR research, explaining that enjoyment and travel intention are influenced by perceived autonomy and perceived relatedness.

2.2.2 Semi-immersive VR (siVR)

Semi-immersive VR (siVR) "projects synthetic or 360-degree real-life captured content onto large screen monitors or the walls [or] the floor of a room, enabling multi-user virtual touristic experiences that stimulate the visual sense and potentially other senses of the user…" (Beck et al. 2019, p. 593). These siVR instantiations are often used on-site for heritage tourism. siVR installations may be experienced by individual users but are more commonly experienced by a group of people, perhaps dozens of them at the same time. With siVR, the user is generally surrounded by multiple moving images and is therefore more isolated from the real world than with the aforementioned niVR with its limited-sized desktop, laptop, or smartphone screens.

Researchers have shown that siVR compares favorably to real-world human guides and increases intention to visit tourism attractions. Additionally, the mode of interaction, ease of interaction and the quality of images are important with siVR systems (Loizides et al. 2014; Pantano and Servidio 2012). Authenticity is conveyed as tourists learn about the real environment through the siVR virtual one (Pantano and Servidio 2012; Refsland et al. 1998). TAM is advocated as a model to undergird research on siVR systems, and presence is suggested as a specific construct that bears investigation (Beck et al. 2019).

2.2.3 Fully-immersive VR (fiVR)

Finally, fully-immersive VR (fiVR) "isolates the user completely from the real world by providing synthetic or 360-degree real-life captured content with a VR headset, facilitating full visual immersion, and enabling virtual touristic experiences that potentially stimulate additional other senses of the user…" (Beck et al. 2019, p. 595). Head-mounted devices (HMDs), such as the Meta Quest 2 and Meta Quest Pro, HTC Vive, and Samsung Gear, with their associated apps, provide examples of fiVR. When using these fiVR systems, the user is deeply immersed in the VR experience, and almost completely isolated from the real world. HMDs fit close to the face, blocking out ambient light and have speakers or integrated headphones for audio to accompany the video content, reducing the user's awareness of ambient noise. HMDs provide a nearly full field of vision for the user, with images that adjust as the HMD's accelerometers detect the user's head movements. Images in the HMD update in near-real time, giving the user the sensation of looking around a virtual space in a way that is similar to the way the user would do so in the real

world. These types of fiVR systems are the focus of this paper and the types of systems on which we will collect data.

While HMDs are typically thought of as hardware for gaming, HMDs are finding applications in a variety of industries. HMDs are being used in medicine to train surgeons, by pharmaceutical companies to visualize new chemical compounds, by the military and police to train soldiers and officers for situations they may face in the real world, by psychologists to treat patients with certain types of phobias, by educators, and also by tourism providers.

In tourism, research on fiVR systems has revealed that such systems stimulate interest in tourism destinations, increase positive attitude toward the destination, and positively influence users' decisions (Marasco et al. 2018; Rainoldi et al. 2018; Tussyadiah et al. 2018). fiVR can be used both to enhance a tourist's experience while on-site as well as in lieu of a visit to the real-world attraction (Jung et al. 2016). Static photos and videos are generally seen as inferior to fiVR (Griffin et al. 2017). Potential tourists are often curious about fiVR experiences and willing to view fiVR promotional content (Marchiori et al. 2017). Rich sensory experiences, including sound, animation, avatars, and high-quality images are all appealing to fiVR users (Griffin et al. 2017; Jung et al. 2016, 2017; Marchiori et al. 2017). Perceived comfort, perceived ease of use, level of enjoyment, and level of immersion all influence intention to use fiVR (Disztinger et al. 2017; Jung et al. 2017). Motion sickness has been highlighted as a challenge to content creators (Hobson and Williams 1995; Jung et al. 2017; Loizides et al. 2014; Slater and Sanchez-Vives 2016).

Presence, which has been identified as a key construct in niVR research (Nam et al. 2022), has also been investigated with fiVR. Interactivity and high levels of attention in the fiVR experience contribute to a sense of presence (Rainoldi et al. 2018; Tussyadiah et al. 2017). Presence itself is positively associated with enjoyment, with change in attitude towards the attraction, with intention to visit, and with revisit intention (Jung et al. 2016; Tussyadiah et al. 2018).

A significant limitation of this research is that much of it focuses on only a single application or single source of VR content. Typically, only one software, application, or website is visited virtually. Additional insights can be gained by comparing multiple types of content or multiple applications in a single study.

Furthermore, very little VR research has been conducted from the User Experience perspective. The Human–Computer Interaction (HCI) paradigm, instead, has been the dominant approach. User experience (UX) is an alternative to traditional HCI evaluation and the usability paradigm. (Hassenzahl and Tractinsky 2006). UX is defined as a person's perceptions and responses that result from the use and/or anticipated use of a product, system, or service (ISO 2019). UX considers the user's internal state, such as their predispositions, expectations, needs, motivations, and mood, the characteristics of the designed system, including its complexity, purpose, usability, and functionality, and the context within with the user's interaction with the system occurs, including the organizational or social setting, importance or meaningfulness of the activity, and voluntariness of use (Hassenzahl and Tractinsky 2006, p. 95).

Thus, while HCI is focused primarily on utilitarian, instrumental, pragmatic concerns, and on functionality, UX considers hedonic aspects such as users'

perceptions, emotionality, enjoyment, aesthetic attraction, and non-utilitarian use (Han et al. 2018; Hassenzahl and Tractinsky 2006).

In tourism, researchers have appealed to the UX paradigm to examine augmented reality (AR), analyzing it in terms of its product features, product character, and the consequences of AR's use, while also considering the context of use (Han et al. 2018). More specifically, the content, presentation, functionality, and interactivity of the AR system are evaluated holistically. The hedonic and pragmatic characteristics of the AR experience are considered as well, with scholars observing that different motivations can cause users to have different perceptions of the technology. Finally, the system may increase or decrease the appeal of the tourism experience and stimulate feelings of pleasure and satisfaction (Han et al. 2018). It is this approach that we take as collect and analyze data to evaluate VR technologies.

To the best of our knowledge, no papers have been published on fiVR from the UX perspective, with only the single aforementioned paper on augmented reality (AR) extant (Han et al. 2018). We extend this work as we take a similar approach to the investigation of fiVR.

3 Methods

3.1 Sample

For this study, data was collected using interviews. Scholars who have studied and cataloged UX evaluation methods note that content analysis of interviews is appropriate to evaluate episodes of technology use when a fully-functional product is evaluated in a field setting (Roto et al. 2011; Vermeeren et al. 2010).

Regarding the specific subjects who participated in our study, we followed the guidelines of Miles and Huberman (1994) from their seminal work on qualitative research. We pursued a strategy of purposeful stratified sampling until we had reached a point of theoretical saturation. Regarding the strata, our goal was to have a sample that varied in terms of gender, age, education level, and nationality. Our goal in identifying these strata was to avoid bias in our findings.

A total of 16 interviews were conducted, with six subjects in the 18–24 year old age bracket, three in the 25–34 age bracket, three 35–44, one 45–54, and three over 55. The total number of subjects is similar to other UX studies of VR systems (Haaksma et al. 2018; H. K. Kim et al. 2022; Law and Lárusdóttir 2015; e.g. Ryan and Siegel 2009). Subjects were contacted directly by the researchers to participate in the study, with the sampling plan designed so that the number of subjects in each age category roughly corresponds to the breakdown of VR users by age (Blagojević, 2023). Additionally, subjects included 6 males and 10 females. Subjects were deliberately selected from across multiple national, cultural, and socio-economic groups. They included Indians, South Koreans, Americans, Palestinians, New Zealanders, and citizens of the United Kingdom. Subjects work as architects, IT professionals, stay-at-home spouses, professors, dental hygienists, and students. Education levels range from those with some university coursework, to bachelor's degrees, to

Table 1 Profiles of Interview Participants

Subjects by age	
18–24 years old	6
25–34 years old	3
35–44 years old	3
45–55 years old	1
Over 55 years old	3
Subjects by gender	
Male	6
Female	10
Subjects by Education Level	
Some undergraduate coursework	6
Bachelor's degree	6
Master's degree	1
Doctoral degree	3

master's degrees, and doctoral degrees. Research subjects were provided monetary compensation in exchange for their participation Table 1.

3.2 Data collection

Before interviews took place, each research subject completed a specified list of tasks in multiple apps using the Meta Quest 2 VR head-mounted device (HMD). The Meta Quest 2 HMD was selected because it is a widely used, state-of-the-art HMD, with over 15 million units shipped as of the third quarter (Q3) of 2022. The price of approximately $400 (as of Q3, 2022) has contributed to its popularity, and this has in turn led developers to create a wide variety of content, applications, and other virtual attractions.

Applications were chosen in the following manner. The researchers used the keywords "tourism" and "travel" to search for applications for the Meta Quest 2 HMD. Of the ten apps that were identified and evaluated through this search during Q3 2022, four were confirmed as heritage tourism-related and included in the study. This indicates that, to our knowledge, only four VR apps in the market could be clearly identified as heritage tourism as of Q3, 2022, and all were included in this study. In addition to these four apps, YouTube 360° VR videos were also included, with three specific locations selected based on the recency of their posting, the quality of the video content (greater than 4 K quality in all instances), and subjects' expected interest in the destination.

Table 2 shows the list of heritage tourism-focused VR apps and 360° content. Heritage tourism is "centered on what we have inherited, which can mean anything from historic buildings, to art works, to beautiful scenery" (Yale 1991). This is echoed by others who state that "heritage tourism can be natural (parks and gardens) as well as physical (country houses and historic palaces)" (Palmer 1999). Similarly, heritage tourism is activity by tourists in a space where historic artifacts are presented (Garrod and Fyall 2001). Thus, heritage tourism could include visits to

Table 2 VR App Descriptions from MetaQuest Store

VR app description	Aspects of heritage tourism present in app
National Geographic Explore VR (https://www.oculus.com/experiences/quest/2046607608728563/)	
1. Antarctica—Head to Antarctica and set off on a thrilling expedition of discovery. Navigate around icebergs in a kayak, climb a massive ice shelf and survive a raging snowstorm as you search fr a lost emperor penguin colony	Beautiful scenery (Yale 1991), natural (Palmer 1999)
2. Machu Picchu—Visit Machu Picchu, Peru and get immersed in amazing digital reconstructions of the ancient Inca citadel. Witness mummy worship, raise a cup of sacred chicha and encounter alpacas as you match Hiram Bingham's photographs from when he rediscovered the Inca citadel	Historic sites (Palmer 1999; Yale 1991), visit to historical sites with historic artefacts (Garrod and Fyall 2001), sites of historical or cultural significance (Moscardo 2009; Trilling 1972)
BRINK Traveler (https://www.oculus.com/experiences/quest/3635172946605196/)	
BRINK Traveler is a virtual travel experience that takes you to amazing natural locations in full 3D to feel like you're really there…. Current locations (~ 500 MB download each): Horseshoe Bend, Pulpit Rock, Arches National Park, Mount Sunday, Lone Pine Peak, Antelope Canyon, Ulsanbawi, White Pocket, Mt Morrison, Cirque de Gavarnie, Bryce Canyon National Park, Mt Whitney, The Wave, Goblin Valley, Dune du Pilat, Alabama Hills, Death Valley National Park, Crystal Crag, Glen Canyon, Haifoss Iceland, and more!	Beautiful scenery (Yale 1991), natural (Palmer 1999)
OtherSight (https://www.oculus.com/experiences/quest/3589600511140268/)	
A museum in Madrid, a back alley from Tokyo, a famous street in Havana…. You will enjoy the real approach of traveling in VR. Discover amazing places around the world captured in breathtaking quality through scanning methods. Be amazed by each place, walk through it, interact with the environment and immerse yourself in the ultimate VR travel experience	Historic sites (Palmer 1999; Yale 1991), visit to historical sites with historic artefacts (Garrod and Fyall 2001), sites of historical or cultural significance (Moscardo 2009; Trilling 1972)
Blueplanet VR Explore (https://www.oculus.com/experiences/quest/3422717251188752/)	

Table 2 (continued)

VR app description	Aspects of heritage tourism present in app
Blueplanet VR Explore is a rich collection of over 40 volumetric experiences of powerful scenic and cultural heritage locations worldwide, ranging from Borobudur Temple in Indonesia to Bears Ears National Monument in the southwestern US. With a high level of photogrammetry and art direction, BPVR offers full spatial presence and mobility within these remarkable locations, some even offering hang gliding flight experiences over spectacular terrains. Interactive features are used to deepen understanding and insight of these fascinating and unique locations	Historic sites (Palmer 1999; Yale 1991), visit to historical sites with historic artefacts (Garrod and Fyall 2001), sites of historical or cultural significance (Moscardo 2009; Trilling 1972), Beautiful scenery (Yale 1991), natural (Palmer 1999)
YouTube 360 VR (https://vr.youtube.com/create/360/) 360º video surrounds the viewer with a complete sphere of video. It is an ideal format for taking your audience to new places and experiences where they can look around in all directions. [In this research study, participants were asked to visit San Francisco, USA Vienna, Austria, Dubai, United Arab Emirates	Historic sites (Palmer 1999; Yale 1991), visit to historical sites with historic artefacts (Garrod and Fyall 2001), sites of historical or cultural significance (Moscardo 2009; Trilling 1972)

museums, sites of historical or cultural significance (Moscardo 2009; Trilling 1972), art studios, cultural festivals (Cho 2012), or religious pilgrimages (Collins-Kreiner and Gatrell 2006). Each VR app was chosen with these definitions of heritage tourism in mind. Details appear in Table 2, where the descriptions of the apps are taken directly from the MetaQuest online store and from YouTube.

Thus, in each app, participants are visiting either historic buildings (such as in Vienna, Austria in YouTube 360 VR), outdoor scenery (such as Antarctic seas in National Geographic Explore VR and in hang-gliding simulations over Iceland in Blueplanet VR Explore), viewing historical artifacts (such as Hiram Bingham's photos of Machu Picchu in National Geographic Explore VR). Some sites are natural while others are physical (man-made).

In addition, users were asked to use First Steps, a Meta Quest 2-provided app that helps users familiarize themselves with navigation, controllers, and other aspects of the VR environment. The list of tasks subjects were required to complete was provided to them in a checklist, as shown in Table 3. Please note that in Table 3, the names of the VR apps are underlined while the tasks users were asked to complete are shown as square bullet points.

Each subject spent approximately 4–5 h using the aforementioned apps and completing the tasks specified in Table 3. After completing these tasks, individual interview sessions were scheduled for each subject. Semi-structured interviews were used to take a comprehensive and holistic approach to system evaluation. The researchers debriefed users in interviews following their use of the HMD and tourism apps

Table 3 Checklist of Research Subjects' Tasks in VR Apps using HMD

Meta quest 2–checklist
Congratulations! you are one of the few individuals selected to experience the Meta Quest 2. Please use the information below as a guide and make sure that you complete each of the steps for the best experience
First steps
Navigate through the "First Steps" tutorial to understand simple but vital information about VR. Through this experience, individuals:
Will understand the usage of the hand controllers, like:
How to hold objects
How to point at objects
How to simulate hand gestures using the controller
Will complete the two simulations provided in the tutorial
Video Game 1 (Shooter simulation)
Video Game 2 (Dance Battle simulation)
National geographic explore VR
Once in the simulation, individuals will have the option to select between two countries to visit first. They must ensure to:
Visit Machu Pichu and complete the tasks provided to enhance user experience. Tasks include,
Taking cover photos from the Sacred Sight of Machu Pichu (Day photoshoot)
Recreating Machu Pichu site from the early 1800's (Night photoshoot)
Visit Antarctica and complete three tasks included in the simulation. Users can choose to either sit or stand during this simulation. (Warning: May induce motion sickness, nausea, or dizziness). The three tasks include:
Kayaking
Mountaineering
Camping
Brink traveller
Once in the simulation, individuals will have the option to select different destinations to visit. They must ensure to:
Travel through the destination preferred and can choose to visit the location during day or night
Use the compass provided in the simulation to identify the hidden points of interest in each destination
Othersight
Once in the simulation, individuals will have the option to select 4 destinations to visit in 3 countries. Individuals can select from the countries below: (Warning: Motion Sickness, Dizziness, and Nausea)
Madrid
Tokyo
Cuba
Participants engagement is through navigating the destination using the thumb sticks on the hand controller. To enhance user experience, participants can listen to the virtual tour guide provided in the simulation
Blueplanet VR explore
Once in the simulation, individuals will have the option to choose from a wide variety of destinations. Individuals must make sure to choose at least one destination from each category
A destination viewed through paragliding

Table 3 (continued)

One destination viewed through short walks
A destination viewed through long walks
A destination viewed without any of the above experience
Youtube 360° VR
Participants can choose to visit three locations provided below. Participants need to watch the video once using the Meta Quest 2 VR headset and once using a TV. The three locations are:
San Francisco
Vienna
United Arab Emirates

(Ryan and Siegel 2009). The self-reporting of episodes of interaction with VR is a UX evaluation method advocated in prior research (Roto et al. 2011).

The researchers then analyzed their interview transcripts, identifying codes across their experiences. Researchers' intentions were to identify whether codes align with those in prior literature, or if new ones emerge. All interviews were conducted face-to-face, with one exception, which was conducted via Zoom. All interviews were recorded and transcribed for analysis. Interview length ranged from 35–55 min. Interviews were structured, following the protocol outlined in Table 4.

4 Data analysis

This study used the qualitative software QDA Miner to assist with manual coding of the interview transcripts and identifying patterns in the interview data (Miles et al. 2020). Data analysis was carried out in the following steps. First, a full transcript of the interview was prepared and compared with the recorded file to guarantee a complete and accurate reflection of the verbal and written communication between the interviewer and the participant (Maxwell 1992). The transcripts were read one by one and detailed notes were made. These notes were then condensed into brief summaries for each participant to provide a degree of pre-coding Saldaña, (2021).

An inductive approach was followed, whereby transcripts were then read multiple times by the researchers to extract particular codes from the interviews, following the principles of content analysis (Brandtzæg et al. 2010). Text identified as belonging to a particular code was coded by the second author individually, before discussions were held between all authors to arrive at a consensus for the codes (Saldaña 2021). Researchers considered specific words, phrases, or implied ideas which related to existing and emerging codes (Creswell and Creswell 2018; Saldaña 2021).

Content analysis facilitates an interpretive paradigm (Jennings 2010; Weber et al. 1978), to allow researchers to explore a topic from the subjective view of the participants, with interpretation being grounded in the real world (Jennings 2010). Summative (Sarantakos 2013) and interpretive coding (Miles and Huberman 1994) were employed to understand the main topics of participants'

Table 4 Interview Protocol

Have you completed each of the items on the checklist?
Approximately how long did it take you to complete the tasks?
Can you please give me your general impression of each app? I will have some more specific questions about them in a moment
Have you used a VR headset prior to this study?
Please evaluate the headset and its operating system based on the following characteristics
Comfort?
Weight?
Battery life?
Resolution (vividness)?
Speed and ease of downloading of apps?
Did you experience any motion sickness (headaches, nausea, or similar symptoms) during this study? If so, how serious would you say those symptoms were? [Likert response and also with open-ended response for comments]
What is your overall opinion about the VR headset?
What is your overall opinion about the VR tourism applications?
Interaction & Navigation (which app one was the best, or the worst? Why?)
Ease of operation (navigation)?
Left scroll bar vs. Right scroll bar?
Other buttons?
Easy to navigate where to want to go?
Consistency of button functions across different apps?
Menu (which app one was the best, or the worst? Why?)
Presentation of menu? (well organized, easy to find)
Operation of menu?
Searching for menu?
Exit out of app?
Stimuli (which app one was the best, or the worst? Why?)
Strong enough to attract and hold your attention?
Interesting?
Enjoyable?
Content (which app one was the best, or the worst? Why?)
Useful? (to learn about the destination)
Diversity? (are enough destinations available to enjoy VR content)
Is AR-type text explanation (where text is overlaid on the images) a good feature?
Which one was most useful? Why?
Which one was most interesting? Why?
Quality of screen (which app one was the best, or the worst? Why?)
Good visibility? (resolution or vividness)
Looks authentic? (look genuine compared with real object?)
Comparison between Oculus and TV? Please name the model and size of TV: _____
Experience: (which app one was the best, or the worst? Why?)
Presence? (did you feel like you were in the location physically?)
Immersiveness? (To what extent were you aware of the real world around you (the room, the chair, other people)? Or would you say that you were you only aware of the VR world you were experiencing?
Feel like real experience? (feel like experiencing something real even in VR)
Did you enjoy the experience?
Would you want try again?
Cost (Meta Quest 2 price and app prices will need to be shared with the participants)
Affordable?
Meta app ($10 -$30)

Table 4 (continued)

Meta Quest 2 ($400)
Meta Pro ($1500)
Apple headsets ($2000—$2500)
Which app did you like the most? Why? Which app did you like the least? Why?
Which features of tourism VR apps did you like the most? Which features of tourism VR apps did you like the least?
Which features of tourism VR apps need to be improved?
If you decide to stop watching the tourism VR apps (or Oculus), what are the reasons?
Which factors are important for tourism VR apps to be more useful and popular?
Headset,
Content,
Screen quality,
Interactivity,
Stimuli,
Fun,
Accessibility
Would you recommend tourism VR apps to your friends?
Are you going to watch the same VR apps again? If so, why? If not, why?
Do you think that VR apps will affect your travel decision where to visit next time? If so, why? If not, why?
Do you think of VR apps as a complementary content for a real trip or as a stand-alone content for itself?
How do you think metaverse concepts and technologies can be incorporated into tourism?

discussions, while still being able to reflect upon these concepts in terms of their original meaning (Jennings 2010). Following the interpretivist paradigm entailed following a "relativist ontology, subjective epistemology, and a naturalistic set of methodological practices" (Denzin and Lincoln 2005, p. 24). Accordingly, participants' real-life interactions and honest, personal, subjective opinions of their user experiences with the HMD were investigated. The personal approach of the interpretative paradigm was also appropriate given the focus of this research on user experience, which by its very definition, could be a very personal and unique experience.

Once the first round of coding was completed, the researchers discussed their codes and coded text to ensure that major differences did not occur between the different coding exercises. While any deviations are not a significant drawback, as this is part of the interpretivist nature of qualitative coding (Saldaña 2021), the researchers discussed any deviations to ensure codes and their coded text were appropriate, consistent, and would stand up to further scrutiny.

An example of the process can be offered with the code 'cybersickness'. After first reviewing the transcripts, it became apparent that users complained about feeling dizzy and nauseous after using some apps. When reading the transcripts a second time to code the data, all instances and descriptions where participants referred to feeling unwell, disoriented, nauseous, weary, or motion-sick were coded as the higher-level code 'motion sickness'. However, after discussion

between the authors, and given the precedent in extant literature, these comments were coded as 'cybersickness'.

The coding of 'Navigation' provides further insight into the coding process and into how the codes' reliability was checked. When coding the data, codes were created such as 'navigation', 'consistency', and 'physical buttons'. After discussing and reviewing the codes, it was felt that all these codes reflected different perspectives on the same overarching 'factor' of 'navigation'. After careful review of the codes and the context, this was confirmed and discussed as generally being clear navigation, through the use of tutorials, but that there were inconsistencies between apps, either in terms of navigation process, quality of tutorials, or functionality of navigation using menus, buttons, thumbsticks, and other movements or actions.

This process of coding, therefore meant that different perspectives of a particular code could be uncovered, discussed as one factor, while still reflecting the various nuances that arose within the code.

To analyze participants' responses to the HMD and fiVR heritage tourism apps, this study extended an extant framework that categorizes factors that affect user experiences into three groups: presentation, content, and functionality (Han et al. 2018; Hassenzahl 2003). Overall user evaluations were considered as well. Table 4 provides an overview of the categories and factors identified, and the remainder of this section presents interview evidence for the categorization.

4.1 Presentation

The first group of factors are related to the presentation of the virtual experiences. This included participants' perceptions of presence, immersion, and authenticity, each of which have been observed in prior literature (Beck et al. 2019). Participants' perception of authentic environments created a sense of presence and immersed them in the content, an observation that aligns with prior VR research in a niVR context (Nam et al. 2022). An additional factor emerged from the interviews relating to participants' cybersickness[1] (Dilanchian et al. 2021).

4.1.1 Presence

Multiple participants offered comments concerning a strong sense of presence from the VR experience.

> Yes. you actually feel like you are in the particular location using the headset although you are just at home. Like for example you're on the street with the tour guide, or you're at Machu Picchu in the mountains. If I just remove the headset, I'm like, oh, okay. I'm not there. I'm at home. [Participant 1]

[1] In cybersickness, the sufferer is stationary but experiences a sense of motion through changing visual imagery. It can be brought on by viewing images on a stationary screen, but cybersickness most acutely observed in immersive VR experiences. In contrast, with motion sickness the user is not stationary, but some aspects of their environment appear stationary relative to the user (such as a car, boat, or airplane).

> First, I started the Antarctica one [the VR application from National Geographic]. It was my favorite. But like it was stressful since I actually felt like I'm there, especially the wind noises. And I felt like the actual air is hitting… me. And I felt cold for some reason. [P9]
> I think that this app had like a psychological impact on me in which I started getting cold since all I could see is snow in Antarctica… [P4]

Feelings of presence seem connected to high resolution and to scenarios where there was a degree of control over users' actions in the virtual environment.

> …when you're on the headset you feel like you're right there in the middle of it like you feel like you're actually there. On the TV didn't look like you're actually there. [P9]
> I kind of felt like I was standing there...and just could look around ...the place and…try different…directions [P3]

4.1.2 Immersion

Participants reported feeling immersed in the VR experience and referred to being unaware of what was physically happening around them, or not being distracted by other aspects of their environment.

> I was totally engaged actually. I mean, you're in the headset. It's not like you can pick up your phone or look around and do something else. You're a prisoner inside the world, which is strong enough to hold one's attention. It was a very interesting experience…even my little brother would come to me and like he's standing in front of me and I don't even know he's there. Like he's literally in front of me and I wouldn't know. [P1]

One participant felt the system so immersive that it triggered a significant emotional response.

> I think that this app had like a psychological impact on me in which I started getting cold since all I could see is snow in Antarctica and like the part where I had to like grab the ropes and like attach it to the thing I don't know what it's called, but the thing that has to do with the tent, it was giving me anxiety because at some point, I couldn't do that. [P4]

Even when participants noted the superior quality of 8 K video on a television, the immersive nature of VR would encourage them to try it again:

> I think the TV was better, but I would use the VR because of immersion. [P10]

Ultimately, immersion was seen very positively by participants and was a vital component of their VR experience.

4.1.3 Authenticity

Participants clearly perceived that their experiences were realistic and genuine.

> And it did give like a really good picture on how these places would look. Even though there are restrictions for VR like you cannot feel stuff,…the weather conditions, but I think it did a really good job…giving a picture on how these spaces would look like in real life. [P2]
> You feel like you're really, really there…. Walls around you and it's so real. You can touch the things, you can pick up the things easily, and that's really a nice experience to have. [P7]
> Also, I think the quality of the picture itself, it gave a good feeling. I mean, when I was close to the penguin, it looked like a penguin to me… like a real penguin! [P16]
> …the VR…gives a really good picture, especially when I visited Iceland…. I feel like if I go to Iceland and visit, this particular place is going to be the same [P2]

Participants felt the experience inauthentic when they reached the limits of their virtual environment or compared their virtual experience to a prior real-world experience of the same destination.

> Blue Planet was really cool to do the paragliding. But at one point I glided over the back of a mountain, and it was...like the scaffolding of the mountain…. So, when I looked back, I could see it was graphics. [P8]
> Obviously walking around [Machu Picchu] myself, I got to see a much broader range of architecture and stone masonry and they didn't get into a lot of the things that I found fascinating [when I visited the site in the physical world several years ago], like the flying steps,…the Hitching Post of the Sun. [P6]

Thus, while participants generally found the VR experiences to be authentic, there were notable limitations to this – namely limitations within the virtual environment, and when users have prior physical experience of the sites they visited. It seemed that the physical experience reduced users' perception of authenticity because the virtual experience did not support their memories of the surrounding atmosphere or complete attractions.

4.1.4 Cybersickness

One negative area which participants described was a feeling of cybersickness that came about from their interactions with the virtual environment. While this feeling was observed in multiple apps, participants felt one app, almost universally, gave them feelings of dizziness, loss of balance, nausea, or headaches. Some participants stated they had to stop and exit the app. The app that generated these feelings was one that users stated as the least likely to be reused.

> It's just one app, Other Sight. Because it's too quick when you move from one place to another. Although I'm standing still, I felt like I was gonna fall…it's mostly like I felt out of balance. [P1]
> Other Sight. I'd say definitely. It was very nauseating…. I'm scared that I'm gonna fall all the time. Because it's nauseating. [P2]
> At the beginning, she was telling me you might experience motion sickness. I'm like, no, no, it's fine. And then 10 minutes into it, I'm like, I can't do this anymore.... I got really tired. I mean, like I felt that I was about to fall. [P4]
> [In the Antarctica Experience of the National Geographic app] For kayaking. It gives you two options, right? Sit down or stand. So for me I was standing. Even when climbing the mountain, I feel a bit dizzy. So, I removed it [the HMD]… it depends on your physical abilities…. but for me it was really bad. [P10]
> The YouTube ones whether it's San Francisco, Dubai or Vienna,…I felt very dizzy.... I was looking around, and I felt so dizzy, and I didn't like it at all. I wouldn't ever try it again…. Other Sight, I liked what they were showing, like the places I visited…. I liked it. But I got dizzy. I got so dizzy…. The headache would continue to like, after two hours…. The motion sickness was the worst, especially in the YouTube one, and Other Sight. [P9]

Some participants commented that the speed with which one moved in the app was off-putting, while others explained that the sensation of walking without physically walking generated nausea.

> I think my brain is telling me you're moving but I'm not moving. You see, it was it was different when, especially with...walking [using only the controller buttons]. It's different than when I was kayaking. When I was kayaking my brain was feeling like I'm really kayaking.... I was moving my hands [to simulate the paddling motion]. [P16]
> I got very motion sick doing it because you're just doing this because we felt like I'm on a Segway or something like that, but really erratic. [P5]

In sum, we observe two overarching findings regarding presentation. First, [*Finding 1*] the majority of participants were impressed with the features of presence, immersion, and authenticity of fiVR, noting a link to resolution, in spite of motion sickness. Even though resolution is an important feature that manufacturers of HMDs use to market their products, presence, immersion, and authenticity are affected by not only resolution but also other design factors and aspects of the VR content. Thus, resolution is only one of many factors that affects users' satisfaction with the VR experience.

Additionally, [*Finding 2*] depending on the types of activities and destinations, as well as users' characteristics, cybersickness was raised as a critical barrier to

use fiVR apps. When participants were asked to choose the least liked apps, nausea was the primary criterion. Therefore, it is vital to control the level of cybersickness depending on the target users, content, and activities.

4.2 Content

The next group of factors emerged from descriptions of the content users would experience while using the VR apps. The factors noted here include entertainment, diversity of content, and the type of guide used.

4.2.1 Entertainment

Participants generally found their VR experiences to be fun and entertaining and spoke of them positively.

> It was fun. It was just simply I can say fun…. And [on the National Geographic Antarctica VR experience] I could go inside the tent, which was so fun. [P3]
> I thought it was really kind of fun. And I would love to be able to do it once in a while…. I was surprised and I enjoyed the climbing and … I'm taking the pictures… I enjoyed that. [The app] Brink Traveler that was oh I really enjoyed all of the Night/Day…. But it was really cool to go to some of those places because I hadn't been to them and … you can't really get to … except through that app. So that was really fun.[P8]

Often, the entertainment and enjoyment were attributed to the interactive experiences offered by the different apps–and non-interactive experiences were not valued.

> [In response to which was your favorite app] National Geographic. I really enjoyed it…. And you had kind of these challenges that you had to accomplish and, you know, do this, take a photo of this… and… you have tasks that you have to complete…. You can wear a hat, you can you climb up the cliff, and you take the photos, you pick things up, you do things like that. So, it … felt like we were just playing a character game. [P5]
> However, Brink Traveler was nice, but okay. You see pictures as real pictures, but there's nothing much to enjoy. You just see the locations which is nice, but I don't know. I didn't feel anything to enjoy… as long as you don't do activities, you don't enjoy it much. [P10].
> Antarctica. If it was just pictures of the penguins, and just the iceberg and the water is just like stable water [with] nothing happening, it would have been boring…. But because these things were happening.... I expect water [hands gesturing showing wave motion]. I expect icebergs falling. It kept me engaged and gave me more feeling of this is real. [P16]

Additionally, enjoyment came from participants experiencing a new environment or activity.

> National Geographic was my favorite app. Because it allows you to experience things like kayaking and camping. For me, I have never done kayaking before, so I really enjoyed it. Plus, I have never thought about Antarctica as a destination to visit… Yeah, it was nice. National Geographic was the best in terms of stimuli. [P10]

4.2.2 Content diversity

Participants referred to content diversity often in the sense of value. That is, content that provided some variety and choice was liked, seen to be enjoyable, and perceived as being valuable.

> I never thought of … kayaking in Antarctica or mountain climbing or even camping there. So that was a new experience…It was really really cool to have like different options in [the app] Blue Planet, and with [the app] Brink Traveler. [P2]
> I never traveled…in winter so I never saw snow or some mountains…. So that was something that was somehow tailored to my interests…. I mentioned, you know, I'd like to explore the ocean…. So visualizing it through a headset or something like that would be interesting…. And that would be something that someone else might prefer. So if it was more diverse, I think it would be nicer. [P4]

This sentiment, particularly in terms of value, also extended to comments participants made about how VR content and apps could be improved in the future.

> Maybe adding new destinations…. [T]hese are enough, but maybe if those apps had…more destinations, that would be…better. [P1]
> If I were…given an option to purchase between [the apps] Brink Traveler as well as Blue Planet, I'd definitely select Blue Planet because…I have a lot more destinations…. [P2]

4.2.3 Audio guide (v. Text guide)

When it came to the type of interface users were exposed to, participants encountered audio descriptions or text superimposed over the images they were viewing. Users sometimes disliked the superimposing of text over images.

> The text I think was disruptive…. [L]ooking at it and trying to figure out what I'm reading, what I'm trying to look at, and all of that is, like, a bit too much…. I would rather see something like visuals and…someone telling me the information. [P4]
> If I really wanted to learn something, I think I would Google it or I would read. I don't think people will rely on these apps to learn…. I think having text kind of interrupts your immersion there. Like, you want to feel that you're actually

there and exploring. If you have a text in the middle of the screen or even at the bottom,…it takes you out. [P15]

Following from this, the use of audio-visual guides such as voice-overs or virtual tour guides were more positively received.

Giving all the information like this in a box might be a bit boring, but in [the app] Other Sight, you will find someone who will talk to you. Maybe this way is more interesting. [P10]
And I learned all this through the voice over okay, I wouldn't have done this if it had been just text. I would prefer a voice-over, over text. [P2]
I liked…Brink Traveler because they got…background details with the narrations. [P3]
I think hearing someone talk about the destination is better because for example, when I was in some location in Blue Planet, all that I was focusing on was the view and the experience. I did not pay attention to the text written. I think it ruins the experience somehow. So it isn't the best feature to be honest. [P13]

It became apparent that participants felt that incorporating audio and visual guides would be much more effective and entertaining to encourage user engagement, interaction, and learning. Some participants also added that the incorporation of additional aesthetics, such as background music, would improve the overall experience.

If you can get to the really nice view together with the music…. It can really create a big impact for your experience. [P12]

Regarding content, we observe that [*Finding 3*] entertainment-oriented features that create a sense of enjoyment and pleasure are a significant benefit and a motivation for using fiVR apps. Most users prefer features that enable interaction between the user and apps over static content that simply delivers information about the destination. Additionally, [*Finding 4*] content diversity is an important feature. Multiple destinations within an app mitigate the issue of boredom that can arise from repeatedly watching content on the same destination. Finally, [*Finding 5*] while text guidance is useful, participants prefer audio or video guidance to increase immersion and enable flow.

4.3 Functionality

Participants offered insight into the functionality and usability of the HMD and apps. Key factors included video resolution, comfort of the HMD, and general operational convenience.

4.3.1 Resolution

The detail and quality of images users were exposed to while wearing the HMD was clearly seen as an important factor. As explained in the methodology section, users were asked to view some content while wearing the HMD and then the same content on a computer or TV for comparison. While participants perceived the HMD resolution to be inferior to a computer or TV, some were more tolerant of this limitation.

> The resolution of the apps was perfect! [P10]
> I think it's somewhat…early stage of VR. So the resolution isn't incredible, but it is very impressive considering how immature the technology is. [P15]

The majority were unimpressed with the resolution, although they still enjoyed and appreciated the experience while wearing the HMD.

> It had a great quality and resolution overall but like whenever you get closer to an object in a location for example, the quality kind of gets worse. But I have a comment now about YouTube. Basically, when watching the San Francisco, Vienna, and the UAE videos on Oculus as compared to a regular TV, the quality and resolution was pretty bad honestly. And then I opened it on my TV. The quality was perfect…[and] my TV, it's just like a normal TV. Not a very big one. So it was…very clear, but when I watched it on Oculus, although it was 360-degree vision and it was so nice to watch, the quality was really bad. [P1]
> And clarity wise, in general,…is not as good as the one I see on TV. On TV is much clearer. If you can that get that clarity and that type of app, that will be amazing…. So sometimes the resolution was really really clear like…the National Geographic rooms in the house [P8]

4.3.2 Comfort

The next aspect related to participants' perception of comfort. This referred to the physical comfort participants felt when wearing the HMD in terms of the fit and weight of the device. Sentiments were mixed, but all users stated an opinion on comfort in one way or another. Examples appear below.

> I think it was pretty comfortable. I don't think I had any issues with comfort. [P14]
> It was really comfortable. But then as you keep using it, you feel like… it gets…heavier, like when you use it for a long time. But that first time I used…it was really nice. I think it's basically because I was very excited to wear it… [P2]
> I found the headset to be heavy on my head. So I…felt hot and kind of sweaty…. After a while I wanted to take it off because of that and also just like a tension headache...[P8]

> If you use it for more than 30 - 45 minutes…you're going to start to feel pain. [P5]
> All in all the experience was great fun. I did find myself getting very tired…. I'm not sure whether that was because I was standing up and, you know, flexing different things that I'm not used to or whether it was brain tired, but after a while, I just couldn't do it anymore. And when it was all done, I…went out to eat one night,…and I…still had a slightly disoriented experience hours afterwards, which I did not find completely comfortable. [P6]

4.3.3 Convenience

Another aspect of the user experience is the ease with which the HMD could be used. This includes battery life and the ease of downloading apps. In interviews, participants provided mixed feedback on the battery life, usually depending on their anticipated or actual usage.

> I tend to do it in breaks of…45 or 30 minutes. So…charging the batteries are…not an issue for me. Because I think I've managed the time for doing this stuff, so it was…pretty okay for me since I was doing it in breaks…. I think it's pretty good. [P2]
> I couldn't do...this all in one day because of the battery life. That's a problem. I cannot finish even…one app within…an hour, because unless the device is fully charged, it doesn't go…over 30 minutes. [P3]
> Battery life wasn't very good. I had to…charge it up several, several times…. [Y]ou were ready to use it and it was time to plug in and…take it off. [P8]
> [The battery life is] not much. For…my son, if he plays with a PlayStation, sometimes he uses it six, seven hours a day [P16]

Downloading apps also revealed differences in participants' perceptions. They rarely commented on the process of downloading, but instead referred to the time to complete a download. Some referred to specific cases within apps, where scenes or environments needed to be downloaded.

> So all six apps I had to download I could download…within 50 minutes or under one hour…. So I think it was pretty cool because there were six apps that I had to download. [P2]
> Downloading. Yeah, that's also one of those, you know, biggest issues…. And also…, to make it quick, we have to wear [the HMD] so…your face gets too hot. [P3]
> Mostly they were fine. But the one with Cuba in Other Sight, that was really, really long…. I think [my husband] stood there for about 10 minutes and… [said] okay, I'm not going to do this. [P8]
> Slow, extremely slow. I remember I had to come later, like next day or something. [P9]

4.3.4 Navigation

Participants frequently commented on navigation as an important part of the user experience. In general, they found the navigation in some apps to be clear and, in many cases, intuitive.

> It had instructions on how to move and teleport from one location to another…. you could press something on the controllers, quite easy actually. Everything is specified in the applications in terms of how to move from a location to another and how to navigate...[P1]
> Now for Blue Planet, I didn't find that difficult. I found that nice actually,… easy to navigate because there was no specific pattern…,it was just more like exploring…. [P4]

Participants commended apps that provided tutorials or guides to the navigation methods, noting that these eased their transition to the app.

> So I think if you do not go through this First Step tutorial [a Meta-provided app to train users on controls and navigation], it can get a little bit confusing and time consuming…because you don't know how to do [activities] and you have to figure it out on your own. [P2]
> And there is usually a tutorial with each app that helps you…throughout the whole process. So it was very easy to navigate…. It's pretty consistent. [P14]

As participants spent more time interacting within different apps, navigation became easier.

> It gets easier to adapt to it when you get more used to the apps and the menu… the first time it's a bit challenging. [P4]
> I think some of the apps had…a very tiny bit of a learning curve, but…as long if you spend like 45 minutes on an app…you've pretty much mastered what you…need to know about the app. [P14]

Apps that provided too many options, rather than providing a more positive experience through greater interactivity and immersion actually created greater complexity in terms of navigation.

> For me it's way too complicated to navigate…. [In the National Geographic app], you need to find a camera… [W]hat should I do? Where should I go…? Shall I press two? Sometimes it works. Sometimes it doesn't…. [Y]ou find this arrow you drag it here and there. You take a picture. I feel like it's a bit complicated. [P7]

The lack of consistency between apps also caused issues when users attempted to transition between different apps.

> Yes, I think I was able to figure out the navigation, but the button functions were not consistent across four different applications. [P13]
> It is confusing. It will be better if they have…alignment between the different apps around these buttons. If it does the same thing then basically you get used

> to the same settings. Otherwise you have to reset your mindset again…because you will get used to one thing and then it's very difficult to change to the other. [P7]
> For interaction and navigation within the apps… It wasn't consistent at all within the apps. You had to learn. I think here in Blue Planet, it was totally different and inconsistent. [P10]

Some concerns existed across all apps and were HMD-related, expressed in terms of the joystick and button orientation, which some users found complicated to operate.

> I found some of the buttons a little oddly placed…. [Y]ou get four different controls for your thumb. You get the joystick and then three different buttons…. [T]hat…"Get Me Out of Here" button is really kind of hard to feel and find. And then....it wasn't always obvious…how to pick something up or how to interact with something. [P6]
> The navigation was fine, but I keep forgetting what each one does and stuff… buttons across apps were not consistent. [P9]

Overall, regarding functionality, [*Finding 6*] the resolution within the apps and HMD was reported as one of the most important factors influencing users' satisfaction. At the same time, users are willing to accept the lower resolution of a VR HMD (when compared to the higher resolution of a TV or computer) because of the immersiveness of the VR experience. [*Finding 7*] The comfort of wearing the HMD is also an important factor. The weight of the HMD and the heat or lack of ventilation affect the amount of time users are willing to spend watching fiVR apps. Clearly, lower weight and less heat (or improved ventilation) will improve the user experience. [*Finding 8*] Convenience in terms of battery life and the download speed of apps need to be improved. Admittedly, variation in download speed exists across users' wireless internet networks, but almost all users expressed a desire for a faster experience. While this was not explicitly stated, users may be comparing their VR app downloads to the time it takes to download smartphone apps. Apps appear as small tiles or icons within the HMD user interface, similar to the way they appear on a smartphone. While VR apps include content with much larger files than in smartphone apps, this comparison and the relatively quick smartphone app downloads may nevertheless be a benchmark in users' minds. Finally, [*Finding 9*] because of the inconsistencies in navigation buttons, menus, and controls across different apps, users experienced difficulties learning and enjoying features of the fiVR apps. Intuitive controls that reduce the cognitive load for users seem to clearly be linked to increased satisfaction. Navigational tutorials and training activities are recommended to support users. These are particularly important when users switch between different apps and navigate different environments.

4.4 Overall evaluation

Throughout the interviews, participants described how impressed they were with the system and how much they enjoyed interacting with the different apps using the headset. Frequently, this is cited as being because of the novelty of the experience:

> It's completely a new experience for me, since this is the first time using a VR headset. So it was quite cool. [P1]
> I think it's a very cool technology…. I think VR is a very exciting technology that shows a lot of promise. [P14]

Specifically, the system's quick rendering of images impressed participants:

> … I was impressed. how fast everything registered. So like, when you turn your head there isn't…a delay before…the visuals change. It actually changes with you. And when you move your hands,…it stays up in real time to [show] where your hands are. [P6]

One frequent observation related to the lack of metaverse-like experiences, particularly the ability to interact with other users or characters, or the ability to use avatars.

> I think I'm going to have an avatar…and we're all talking and doing exercises together or something cool…. That'll be very interesting. [P8]
> [Regarding VR for education] You're sitting there…even in a class you know? To see your professor right there and talking to you. That's really entertaining. [P7]

It is noteworthy that participants did enjoy the activity-related interaction offered by apps and would have liked to see more interpersonal interaction features. While some of these features such as avatars are already available through educational applications or Meta's VR videoconferencing tool, more will likely become available as the metaverse grows in user numbers and available applications. This leads us to observe that [*Finding 10]* even though the metaverse is of growing importance, currently it is hard to find features such as social networks and avatars in fiVR tourism applications.

We also note, not solely on the basis of the quotations immediately above, but on those throughout this section, that [*Finding 11*] overall evaluations by participants are very positive even though some limitations are identified. On the basis of our interview data, we conclude that fiVR applications have considerable potential in tourism, with the potential increasing as identified limitations are overcome.

Specifically, regarding participants' thoughts and intentions for their future use of VR, they stated that they were willing to recommend the experience and would be willing to use the HMD again. From a tourism perspective, no participant felt that they would replace physical travel with the virtual alternative. They would,

however, use the virtual experience before or after their trip to either help them with planning, or help to relive their experiences.

> I don't think it can replace travel. The real experiences…still definitely cannot be replaced. [P7]
> I think visiting places you've already been can be cool. It can help you re-experience. I don't think it can be standalone. [P5]
> …it's been 40 years since I was in Carlsbad [Caverns, an attraction that appears in the Blue Planet app],… but I can remember…a lot of the things that I saw and it was,…kind of fun to refresh your [mind]. [6]
> … as a way of kind of checking out a place before you go or to see if that's something you want to do or to get ideas about where you want to go…. [Or to] use VR to kind of remember something you visited in the past… I don't think I could go through an entire museum with it on my head. I think I wouldn't like that. But if I could …put it on for a few minutes to get a little more information, [such as]…here's what the site looked like 200 years ago. [P8]

The only exception to this, where participants said VR could replace physical travel would be when viewing destinations they would not visit due to cost, mobility limitations, or political restrictions.

> If you're elderly or something and you can't do a trip, then I think it's a good substitute,…like elderly people who can't go there anymore…. Other locations that I won't ever go to like North Korea, Syria,…. [Or]…where there's volcanoes or difficult terrain…. So those kinds of places could be really good…. And also, I think adventure stuff…. I personally am not a downhill skier…. I never learned and I'm terrified of it,…but I would love to do it…[and] get a sense of what is like without having to put my life at risk,,,, So maybe those kinds of things,…or skydiving. [P8]

Thus, [*Finding 12*], participants consider that fiVR tourism apps support and complement travel, but are only substitute for it in certain circumstances. Such apps are useful and provide users with information about possible destinations where they cannot or will not visit physically.

Regarding costs, some participants felt that the price of the sample unit (Meta Quest 2, at approximately US$400 at the time of the interviews) was reasonable given the features offered.

> [app and HMD] it's a reasonable price for…the picture or the picture quality resolution, the sound effects, everything is…very good. And…for a person who has not traveled much to get to know all these places within…a short period of time. [P2]

Frequently, participants' perception of price and value were conditional upon the features offered by the HMD and the r*espective apps available.*

> I think with those [HMD] devices, the maximum I can spend is $600 to $700…. [and] about the apps, it depends on the diversity. So if you tell me the National Geographic is like $30 or $40, or even $50, but I can have 100 differ-

ent experiences which means go to different places….then yes, definitely. No problem. But if it is only one thing, you know, like [only] Antarctica for $30 then...I think it would be too much. [P16]
I would definitely spend $10 to get the National Geographic, which I really enjoyed. [P14]
Yes, it [the HMD] is affordable but I wouldn't really purchase it. Because I feel like I wouldn't…use it on a daily basis so I might just try it out for fun by borrowing it from someone or something but I won't purchase it. And I also feel like it's a one time thing. [P13]

When it came to more advanced and specialized HMDs, such as the Meta Quest Pro (priced at $1,500 as of Q1, 2023) or the Apple Vision Pro that is to be released in 2023 (with an estimated price of $3,500), participants were less interested, with the main comment being they did not see significant additional value, and with concerns over the extent of their usage.

Maybe I can borrow it…but then no, not spend that much money…. [P3]
[for new Apple HMD] I'm not a huge gamer…. I don't spend a ton of time on YouTube. I don't think there would be a lot of utility for me. So I probably wouldn't, personally…. I already use a lot of Apple products like my iPhone,…so if certain applications were incorporated into that, it might be different, right? If those were integrated in I might be more open to it but probably not at that price. [P5]
But if…[the Meta Pro HMD]…is considerably lighter and much more comfortable to wear, then it might be worth it… I can see that there might come a time when the price [$1,500] is down low enough that I might be willing… [P9]
[For new Apple HMD] It is different from a cell phone, $1,000. We can't live without it…. For Apple…we will wait till all the bugs are worked out and everybody has one and then eventually jump on the bandwagon. [P8]

A couple of participants continued to comment on cost to say that having the ability to rent an app or environment and pay a subscription fee would be more appealing.

I don't think I personally would want to invest in the applications unless I have a deep, deep interest in a specific one. But…let's say they want to give us a pro version where I can have access to different movies…and shows and…access Netflix or something like that. And let's say it comes with a fee, let's say $10 a month, just like the Netflix subscription. I think I would want to invest in that. [P4]
I mean sometimes you buy it [a film] for $20 but rent it for $7,…so I prefer to rent it, watch it and then it disappears because I know I'm not gonna go back to it anymore. So the same with apps…for example, National Geographic, I prefer to pay a subscription monthly or yearly, but…they keep on adding more experiences. [P16]

Table 5 Classification Framework of UX Factors for fiVR Heritage Tourism

Category	Presentation
Factors	Presence—explains the feeling of "being there" in a specific location, such as a VR-generated real-world location or a wholly synthetic computer-generated world (Ijsselsteijn and Riva 2003; Sanchez-Vives and Slater 2005)
	Immersion – addresses the degree of isolation from the real world (Beck et al. 2019) [as used in the niVR, siVR, and fiVR categorizations presented in the Literature Review]
	Authenticity – refers to the authenticity of objects projected in VR in terms of users' imagery, expectations, preferences, beliefs, powers, etc. (Nam et al. 2022; Wang 1999)
	Cybersickness – dizziness, headaches, nausea, and/or vertigo brought on by the sense of motion for the (stationary) user that is brought on by changing visual imagery (Dilanchian et al. 2021)
	Content
	Entertainment – hedonic features such as fun and enjoyment that users experience while interacting with VR apps
	Content Diversity – the diversity of destinations and activities that users can experience with VR apps
	Audio Guide (vs. Text Guide) – how users are guided to obtain information out of audio or text while using VR apps
	Functionality
	Resolution – visual detail and quality of the image displayed in the HMD Comfort – physical comfort or discomfort experienced while wearing the HMD Convenience – battery life of HMD and ease of downloading apps (Chan et al. 2010)
	Navigation—how users interact with VR menus by using various buttons in the controllers (Webster and Ahuja 2006)
	Overall Evaluation
	Satisfaction—pleasant feeling that users experience when using VR apps and HMD Price—cost that users pay to buy HMD and VR apps

Thus, [*Finding 13*], price (or value in relation to cost) is a very important factor that affects the decision to purchase fiVR tourism apps and HMDs. As for apps, users consider the content of apps as well as price, clearly a value consideration. And as for HMDs, users are more price-sensitive than with other devices such as smart phones since HMDs are not perceived to be essential for daily usage. In light of this, it seems unlikely that users would purchase HMDs solely to experience fiVR tourism apps. Additionally, [*Finding 14*], participants generally do not want to use the same app multiple times unless there are new locations or experiences. Novelty and entertainment are important motivations to use fiVR tourism apps.

4.5 Quantitative Evaluation

This study identified 13 factors across four categories in assessing the user experience with respect to the latest fiVR tourism apps (listed above in Table 5). Following earlier research (Han et al. 2018; Hassenzahl 2003), findings are organized

Table 6 Survey Result from Participants

	fiVR Tourism Apps						YouTube 360° Videos			
	Machu Picchu	Antarctica**	Blue planet	Other sight***	Blink traveler	Average ****	San Fran	Vienna	Dubai	Average
Presence	3.93	**4.27**	3.36	**3.25**	3.88	**3.78**	3.00	3.25	2.92	3.06
Immersion	4.03	**4.77**	3.56	**3.31**	3.69	3.63	3.63	3.67	3.58	3.63
Authenticity	3.93	**4.07**	3.75	**3.63**	4.06	**3.89**	3.00	3.08	3.08	3.06
Real Experience	3.67	**4.07**	3.44	**3.13**	3.63	**3.58**	3.13	3.33	3.08	3.18
Stimuli	4.00	**4.53**	3.44	3.56	3.13	**3.73**	2.54	2.58	2.42	2.51
Fun	3.93	**4.87**	3.25	**2.88**	2.88	2.81	2.92	2.83	2.67	2.81
Useful. of Content	3.47	3.33	3.19	3.50	3.56	3.41	3.75	3.75	3.58	3.69
Resolution	4.47	**4.52**	3.69	4.00	3.48	**4.21**	2.88	2.75	2.57	2.79
Navigation *	2.93	2.93	2.81	**2.81**	3.19	**2.94**	2.42	2.50	2.50	2.47
Interactivity	4.07	**4.57**	2.73	3.07	3.07	**3.50**	1.82	1.92	1.82	1.85
Satisfaction	3.73	**4.60**	3.31	**2.75**	3.31	**3.54**	3.00	3.08	3.08	3.06

*For navigation, the higher the score, the more difficult to navigate

**The bold font in this column represents the highest score among fiVR apps

***The bold font in this column represents the lowest score among fiVR apps

****The bold font represents the score of fiVR app higher than that of 360° video

according to the fiVR product features of presentation, content, and functionality, as well as users' overall evaluation. We also follow this prior research in commenting on the character of the product, the context in which it is used, and its consequences.

After the interviews, survey questions on a 5-point Likert scale were presented to the participants to quantify the overall characteristics of the apps. Table 6 shows the results from the survey data, revealing perceptions that are consistent with the qualitative analysis presented in Sect. 4.

Among the tourism apps, National Geographic's Antarctica had the highest satisfaction score (4.6) while Other Sight had the lowest (2.75). Antarctica shows the highest score with regard to all factors except usefulness of content (3.33) and ease of navigation (2.93), which implies that gamification features such as fun (4.87), immersion (4.77), and stimuli (4.53) are important factors – even more important than the usefulness of content. On the other hand, Other Sight, the app with the lowest level of satisfaction, shows the lowest values in six factors such as presence, immersion, authenticity, real experience, fun, and navigation. These results seem related to the high rating for cybersickness for this app. Nevertheless, the fact that navigation (2.81) and fun (2.88) are the lowest among other apps implies that Other Sight also lacks gamification features, thereby failing to satisfy VR users.

One of the interesting findings is that users' average score for resolution (4.21) is higher than the average scores of any other factors. Also, even though the same HMD, Meta Quest 2, was used for all users and all apps, the evaluation of resolution across five apps varies from 3.69 to 4.52. HMD manufacturers have worked to improve the resolution of the HMD to enhance user experiences even though it increases the price. However, this survey indicates that improving other factors may lead to higher satisfaction while the resolution can be managed by altering the content of the apps.

Compared with YouTube 360° videos, participants reported higher average values for fiVR apps. Three exceptions are immersion, fun, and usefulness of content. For immersion, the average value is the same (3.63) which implies that the participants experienced the same level of immersion between fiVR apps and YouTube 360° video. For fun, the average value is also the same (2.81), which implies that YouTube 360° videos still provide the same level of fun and enjoyment without any interaction when users watch those content using the HMD. For the usefulness of content, participants evaluated YouTube 360° videos as more useful (3.69 vs. 3.41 for fiVR apps) even though they experienced the same level of fun.

5 Discussion

While presence, immersion, and satisfaction clearly appear in extant literature, several of our factors do not appear in prior literature. Content diversity, convenience, and price have not been discussed in the context of VR tourism research and represent contributions. Authenticity has been only briefly explored. Other variables (entertainment, audio guide v. text guide, and navigation) may be new or may represent aspects of perceived usefulness (PU) and perceived ease of use (PEOU) and hedonic information systems. Others are new to academic research (resolution and

Table 7 Classification of positive and negative user experience factors

Category	Positive factors	Negative factors
Presentation	Presence Immersion Authenticity	Cybersickness
Content	Entertainment Audio guide	Content diversity
Functionality		Comfort Resolution Convenience Navigation
Overall evaluation		Price Satisfaction

comfort), and have heretofore been mentioned only in marketing materials or trade journals. We will now discuss each of these in turn.

Authenticity is an important topic in tourism research, one that emerged from research on visitors' perceptions of museums (Trilling 1972) and has since been applied to touristic experiences and objects in general (Wang 1999). Tourists assess art, artifacts, food, clothing, ceremonies, festivals, and attractions in terms of their genuineness or realness, and thereby form a perception of authenticity to inauthenticity (Sharpley 2018). If authenticity influences tourists' levels of satisfaction in real-world settings (Moscardo & Pearce 1986), it seems plausible that it will influence their satisfaction with virtual experiences as well. How can virtual touristic experiences – which are clearly not objectively authentic and real – nevertheless provide users with the perception of authenticity? If high-quality replicas of artworks can be perceived as authentic by tourists (Schwan & Dutz 2020), can computerized virtual experiences also be perceived as authentic? In a study of non-immersive VR (niVR) tourism sites, activity-related authenticity (but not object-related authenticity) was shown to influence satisfaction (Nam et al. 2022), while in another, authenticity was shown to influence behavioral intention (M. J. Kim et al. 2020). We therefore call for further investigation of this factor in future studies of VR in tourism.

Entertainment is a new factor that has not been considered in studies of VR in tourism. However, it appears to be similar to perceived enjoyment, a construct that has been investigated in IS Research (Van Der Heijden 2004). There, perceived enjoyment is defined as the degree to which consumers obtain fun from hedonic information systems (Van Der Heijden 2004). The introduction of this concept to tourism research is an important contribution as well, one that bears additional investigation. To the extent that a VR app for tourism can be considered as a hedonic information system, findings from IS may be relevant.

Content diversity is identified here as the diversity of destinations and activities that users can experience with VR apps. This, too is a new factor that has not been previously identified. Much existing research asks users to evaluate a single app and describe their impressions or to complete a survey. Such research scenarios are limited in that they explore only a brief episode of use. In such scenarios, diversity of content may not be important. Subjects to not have enough time with the content to

become weary, jaded, or bored. We suggest, however, that researchers who desire to understand continued usage or positive perceptions that extend beyond a limited episode include content diversity within their research models.

Within the apps, the presence of audio or text instructions to guide users was an important consideration – and also one that has not previously been explicated by VR researchers in the tourism context. While many of our subjects preferred voice/audio directions regarding objects and navigation in the virtual world, we recognize that there could be differences from one user to another based on users' learning styles (Fleming and Mills 1992). This factor represents a contribution not only because of its novelty, but also because it raises additional questions for researchers to explore.

Price may at first seem like an atheoretical addition to the discussion of technology usage. However, we observe that theories such as TAM/UTAUT or task-technology fit (TTF) are limited in their application. If a research subject is invited to use a VR headset and apps, then only asked about PU and PEOU, results may indicate strong positive perceptions and augur for extensive use. But what if the HMD is the new Meta Quest Pro ($1,500 as of Q4, 2022), or Apple's Vision Pro ($3,500)? Research subjects may give the device high marks when it is presented to them in a lab by researchers (at zero cost to themselves), but have no intention whatsoever to actually use the device (at a significant cost to themselves) after the study concludes. Economic theories need to be incorporated into discussion of technology use, including in tourism.

Comfort, defined here as physical comfort or discomfort experienced while wearing the HMD, and convenience, which in this study is the battery life of HMD and the ease of downloading apps would similarly not be identified in traditional HCI studies that focus on usability – nor in studies using TAM/UTAUT. The limits of these approaches become visible when taking a more holistic perspective on the user experience.

Additionally, we classify the factors into two groups, those that positively affect the user experience and those that negatively affect it. Table 7 shows the lists of positive and negative factors, as described by the participants. For instance, comfort is classified as a negative factor because multiple users commented on the weight of the HMD on their head, the difficulty achieving a proper fit, the heat generated by the device, and the uncomfortable padding where the device was in contact with their faces. Other factors are classified in a similar manner.

Findings from the analysis of participant interviews reveal five positive factors and eight negative factors. Participants noted that presence, immersion, authenticity, entertainment value of the content, and the quality of the audio guide positively influenced their user experience. In contrast, cybersickness, lack of content diversity, lack of comfort, low video resolution, lack of convenience, difficult navigation, and the need for a lower price for the HMD negatively influenced their user experience.

Providers of metaverse tourism apps can maximize the user experience by observing, accentuating, and focusing on the positive effects while simultaneously working to minimize the negative effects. However, as they do this, they will observe that this seemingly obvious approach of maximizing positive factors and minimizing

negative ones is not entirely straightforward. Some positive and negative factors are closely interrelated. Maximizing a positive factor at times also increases a negative factor, and vice-versa. For instance, increasing the sense of immersion that users feel (a positive factor) simultaneously contributes to a sense of cybersickness (a negative factor). In multiple cases, there are dilemmas presented to HMD and fiVR app providers that must be addressed to provide the best possible user experience. We now describe the conflicting relationships between positive and negative factors for the development of fiVR tourism solutions.

5.1 Dilemma of price

To enhance the user experience in metaverse heritage tourism, it is important to enhance resolution, comfort, content diversity, and convenience, but each of these will also increase the price. The dilemma is that users will not purchase immature technology at a high price, while manufactures have to increase the price (or at least maintain it at a high point) to improve resolution, comfort, content diversity, and convenience. This aspect of the dilemma of price likely means that it will take longer for fiVR solutions to be common and widely used.

This study used the Meta Quest 2 HMD (previously branded the Oculus Quest 2) to test user experiences. Participants responded that the price ($400 as of Q3 2022) was affordable even though several limitations exist. Participants also responded that the price of the Meta Pro HMD and the Apple Vision Pro, would be unreasonably high regardless of improved features. Participants reported that they do not use the HMD as a stand-alone device on a daily basis, and therefore the prices of the newer devices are not justified. While one participant (an architect) responded that one of the new high-end devices might be appropriate at his practice to demonstrate a building or other design project to a client, this is a situation where quality is the supreme consideration and where the price of the HMD is a tiny fraction of the overall price of the design project. All other participants saw the current state-of-the-art Meta Quest 2 as adequate for non-commercial use.

Additionally, the relationship between content and price was noted. Even though participants had positive perceptions of several fiVR tourism apps, they considered price as a critical factor for purchase and continued usage. While the prices of the HMD and apps are affordable, without a consistent stream of new content, users would be reluctant to pay even the current price. Restated, users do not want to use the same apps multiple times. The experience is monotonous if only the same content, locations, and features are available.

Interestingly, recurrent payments, such as for new apps, for experiences within apps, or for subscriptions providing access to new content may increase the likelihood of fiVR tourism app use. Thus, an additional nuance to this dilemma of price is that while users generally want lower prices, they may simultaneously see recurrent fees for content as justifiable, and perhaps even as desirable. Streaming media services such as Netflix, Amazon, Spotify, and other services are normalizing the subscription model for online content, with potential positive implications for VR.

5.2 Dilemma of cybersickness

When participants chose the app that they liked the least, most selected the one that led to the highest level of cybersickness. Some users stopped watching and rated it as the worst app, even though they felt a higher degree of presence and immersion than in other apps and videos. Thus, even though presence and immersion are positive factors that contribute to a better user experience, sometimes they are closely related to cybersickness and may paradoxically yield a very low level of satisfaction.

Troublingly, improving the quality of screen resolution – which increases users' sense of presence, immersion, and authenticity – sometimes leads to a higher level of cybersickness. While feelings of cybersickness depend on the type of VR content and the activities the user is engaged in, it will be difficult for creators of VR experiences to completely remove the possibility of cybersickness. If VR users want high levels of presence and immersion and at the same time a low level of cybersickness, fiVR apps may need to sacrifice the full range of entertainment features. Designing less-interactive VR content can reduce cybersickness, but fun and enjoyment may be lost.

Thus, the dilemma here is that it is challenging to provide a high level of screen quality and resolution in the pursuit of presence, immersion, and authenticity without triggering cybersickness. It is similarly challenging to provide highly interactive experiences where users perceive fun and enjoyment without triggering cybersickness. Perhaps an AR-type HMD which provides immersive content while simultaneously allowing the user some visibility of the surrounding space provides a way forward from this dilemma.

5.3 Dilemma of gamification

When participants were asked to choose the app they enjoyed the most, they chose the one which has the most entertaining features and the one that was rated highly on fun and enjoyment. The entertainment feature is the most important factor even for heritage tourism apps. Therefore, the integration of gamification features is a key factor to enhance the user experience. This result implies that interactive and dynamic interfaces lead to more fun and enjoyment.

To maximize the user experience, fiVR tourism apps need to integrate gamification features. However, the dilemma is that navigation becomes more difficult for active interactions, something that negatively affects the user experience. Gamification features require users to learn new controls and actions to access the features, functionality, and content of the app. If the majority of users are eager to endure the learning cost, tourism apps will increase in popularity. If not, app creators may consider reducing active interaction to reduce users' cognitive load, even though this may yield less fun and enjoyment.

The dilemma is that the positive relationship between interactive gamification features and high learning costs make it difficult for fiVR tourism solutions to target the large potential audience. Users' behavior and expectations may not change

within a short time horizon. Content creators will need to balance the need for simplification and standardization of navigation with the need for fun and enjoyment.

The three dilemmas show that it may be challenging to develop popular tourism apps that satisfy the pool of potential users for metaverse technologies like VR. To summarize, for tourism fiVR apps to flourish, three conditions need to be satisfied. First, VR technologies for HMDs will need to provide better comfort and convenience to users while maintaining an acceptable price. Second, VR content should be designed with the highest possible resolution quality to maximize perceptions of presence, authenticity, and immersion, but without triggering cybersickness. Third and finally, navigation that is consistent across apps or otherwise builds on users' stored knowledge will enable the development of apps that are interactive, gamified, and satisfying. The growth of the metaverse depends on hardware and software creators' ability to address these design dilemmas.

5.4 Limitations and future research

As with all research, this study has certain limitations. The primary one relates to the device and apps that the participants experienced. While this was an exploratory study on the metaverse and noteworthy insights have been gleaned, it is important to remember that only one HMD, a Meta Oculus 2, and four VR apps were experienced by users. It is possible that alternative devices and apps may offer participants different experiences. Additionally, while robust quantitative and qualitative data was collected, with participants collectively engaged in app use and interviews for over 100 h, larger samples and longer usage time for examination could provide additional insights.

In light of these limitations, future research should engage users with additional apps and alternative HMDs to provide more insight on the generalizability of the issues participants raised here. Large sample sizes and longer usage times should be considered as well. Furthermore, users' past experiences can be considered as well. For instance, experimental groups could be created with participants using a VR device either before or after physically visiting a destination. Perceptions of the VR experience may differ based on whether users have or have not experienced the real-world destination before use. While this study recorded some participants thoughts on this, this variable was not directly controlled.

Finally, while this study is exploratory and does not construct a theoretical model of VR app usage in tourism, it does lay important groundwork. When the novel findings here are paired with existing research, the future offers new opportunities for theoretical development. We suggest that a framework such as the stimulus – organism – response (SOR) model allows for factors from causal models in HCI studies as well as additional factors from more holistic UX studies to be integrated. It also provides space for various theories grounded in psychology, economics, and decision theory to explain links between factors.

6 Conclusion

As researchers' and practitioners' interest in the metaverse grows (see Buhalis et al. 2023), there is increasing need to understand potential users' experiences of the hardware and software that form the basis of the metaverse. This is one of the first studies to adopt the UX perspective to empirically examine the VR technology that underlies the metaverse. It is also one of the first to test multiple apps in a single study. In the findings presented by this research, we have shown that it is important for developers to consider users' experiences of VR apps and devices. Continued emphasis on presentation, content, and functionality, while maintaining a focus on users' experience rather than simply on technical capabilities of the hardware and software, will yield benefits across the spectrum of stakeholders. HMD manufacturers, app creators, and tourism managers can create a virtuous cycle of improvements through collaboration on the user experience. As practitioners and researchers build on this study to develop deeper insights and more clearly understand users' perceptions, it will be possible to address issues and envisage the manner in which the metaverse will develop and be experienced in the future.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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