Heritage Science

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Why people use augmented reality in heritage museums: a socio-technical perspective

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Abstract

With the development of digital technologies, the use of augmented reality in the tourism sector has received increasing attention. However, the understanding of the factors influencing tourists' post-experience intention with augmented reality devices is incomplete and there is a lack of empirical research. This study explores the impact of AR technical factors, individual factors and situational factors on users' post-experience AR usage intention and destination revisit intention through satisfaction based on a socio-technical perspective. The survey data collected from 254 visitors who visited the Liangzhu Museum using the corresponding AR glasses were analysed, and the results showed that the novelty of the technical aspect, the technology trust of the individual aspect and the aesthetics, education and authenticity of the situational aspect influenced visitors' AR usage intention and destination revisit intention through satisfaction. This study has an impact on future research on the application of augmented reality technology to heritage museums.

Keywords Augmented reality, Heritage museum, Socio-technical perspective

Introduction

Heritage tourism is one of the most common forms of tourism, and its experience is determined by the personal connection people have with the destination they visit [1]. Over the past few decades, digital technologies have received a great deal of attention and widespread usage. They encompass the integration of information and technology into physical objects, affecting almost all areas through related applications, including augmented reality (AR), artificial intelligence, robotics, big data, etc. [2, 3]. The continuous development of digital technologies is reshaping our daily lives and changing the human-technology interaction between the real and the virtual, especially in the experience-focused tourism industry [4–6]. As the function of modern museums shifts from preserving artefacts to facilitating visitor experiences and creating unique educational content, museums need to connect visitors, exhibits, and devices through the application of digital technologies such as AR, expanding the creative content and experiential space of exhibitions [7, 8]. The experience of heritage tourism activities includes sites visiting, artefacts exhibitions and specific interactions. However, the satisfaction and revisiting behavior of heritage visitors are not only related to the economic benefits of museums, but also crutial to the conservation and sustainable development of heritage sites. Therefore, better ways of combining the tourism experience with heritage conservation will be an important direction for the future.

In recent years, heritage conservation often applied digital technologies to preserve physical artefacts and sites, and to improve user engagement [9, 10]. AR technologies provide an immersive audio-visual experience for users through physical devices and

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embedded software. The benefits of adopting AR in heritage tourism are not limited to preserving the content of the site digitally, but many benefits in terms of tourism economy and user experience. AR can extend and complement the artefacts that cannot be displayed and that have been damaged. During a visitor's tour, the AR device serves as a virtual interpreter, providing additional information about the artefacts that cannot be explained by a single text. In [11], the authors argued that small heritage museums that rely on the benefits of admission need to provide visitors with enjoyable experiences to increase satisfaction and word-of-mouth to attract new target markets. Therefore, the adoption of emerging technologies can increase the competitiveness of museums, thus further enhancing experience management and heritage conservation. Thus, there are great application prospects for the use of AR in museum scenarios. Due to the continuous improvement of AR underlying technology and application interface, the combination of AR technology and museum culture is becoming increasingly attractive to tourists and is gaining social attention. This enables the public to realize the charm of the combination of innovative technology and traditional culture. The usage of AR in museum has enhanced visitor experience.

Currently, some heritage museums use AR technology. For example, the Kyoto National Museum uses AR devices to enable visitors to view virtual artefacts and holograms of monks moving around the museum space. The Palazzo Madama in Rome provides AR service throughout one's journey with entry directions, road signs, video explanations and holographic figures. In the AR exhibition of the Mogao Caves of Dunhuang, visitors are permitted to enter a room-sized virtual space to tour a recreated view of the interior of the Mogao Caves. However, despite the rapid progress of AR applications in heritage museums, there is little research focusing on tourists' AR usage behavior. In the field of retailing and customer research, recent studies on AR have discussed certain implementing scenarios, such as clothing, cosmetics, etc., and most studies have focused on mobile AR games [12–15]. In the case of heritage museums, previous research employed the technology acceptance model (TAM) to empirically investigate the impact of perceived ease of use and perceived usefulness on visitors' willingness to use AR devices [16–18]. Alternatively, previous published studies are limited to explaining visitors' satisfaction and subsequent post-experience behavioral intention from an integrated perspective of personal perception and technology quality [19, 20]. Therefore, building on these findings, we consider AR usage behavior from a socio-technical perspective and investigate the factors influencing visitors' AR usage intention in heritage museums.

The effectiveness of AR technology in museums is not solely dependent on the technology itself, but also on the users and the context in which it is used. As a result, it is crucial to take into account the technological as well as social reasons behind why individuals utilize AR technology in museums. This study aims to address the influential mechanisms between technical features, personal features and situational features and AR users' post-experience behavior intentions from a socio-technical perspective. We propose a conceptual framework to test their causal relationship with satisfaction and to investigate the effect of satisfaction on visitors' post-experience AR usage intention and destination revisit intention. Moreover, this empirical study provides useful insights and a theoretical basis for how visitors and museums can enhance the experience feelings. Finally, we conclude the paper with limitations and ideas for future research.

Literature review

AR in cultural heritage museums

Since the twentieth century, cultural tourism has been largely defined as a form of special experience tourism [21]. Reisinger [22] argued that cultural tourism encompasses historical and heritage tourism, which enhances the cultural experience of tourists. Heritage tourism is part of the most widespread and ancient forms of cultural tourism and is reaching a certain level of maturity with the growth of tourism. Visitors are no longer satisfied with appreciating the intrinsic value and inherent culture of a site, but prefer to combine what they visit with their knowledge to create a special experience [1]. The progress of heritage tourism is partly dependent on technological advances and innovation. Many heritage destinations are currently prioritising technological innovation to improve the visitor experience, utilising metaverse technology, electronic guides, and other methods.

AR is a technology that superimposes synthetic images onto real images. It implements analogue simulation processing of physical information that is difficult to experience in the spatial scope of the real world and superimposes virtual information content to be applied in the real world. This process enables us to perceive sensory experiences beyond reality. As an interactive tool, AR provides a virtual layer between the user and the physical environment. This gives the user the additional information they need to do the activity more successfully, which improves their audio-visual and cognitive processes [23, 24]. The difference between AR and VR is that AR augments the view of the real world with virtual features, whereas VR creates a completely isolated virtual world; while displaying virtual elements, AR cannot

affect the user's view of the real world [25]. Consequently, AR devices necessitate more complex designs than VR, both in terms of optical technology and location recognition technology.

In recent years, with the rise of the artificial intelligence industry, the use of cameras as simple video tools is no longer sufficient for all areas. Augmented reality is already used in many fields, but its application in tourism is relatively less prevalent than in other sectors such as medicine and retailing. Therefore, it is necessary to improve visitors' engagement and experience through an effective combination of augmented reality and tourism. The current researches by scholars on the application of metaverse technology to tourism are summarised in Table 1 below.

Previous research has considered two types of mobile augmented reality (MAR) that are simple to use: mobile augmented reality apps and head-mounted devices (HMDs). Initially, MAR required special hardware and software systems, but the experience of augmented reality on mobile and handheld devices has improved significantly in recent years [26]. MAR apps offer users further engagement experience and potential mobility, enabling real-world visualisation of 3D models that have a unique and positive role in creating memorable travel experiences (MTEs) for visitors [20]. Compared to MAR, head-mounted AR gathers data immediately in front of the operator's field of view, freeing up the operator's hands and enabling a deeper level of immersion in the merging of virtual and reality worlds [7, 27]. Although HMDs were foumerly more frequently used in VR technology, the number of lightweight head-mounted AR applications is steadily rising due to the quick development of metaverse technology and the steady maturation of mobile computing and interaction methods.

The widespread use of these two methods is provided to apply AR more successfully to the tourism industry, bringing it special benefits.

Over the last two years, the development of computer vision technology, graphic rendering technology, and the computing efficiency of HMD devices have increased the potential of the metaverse. Emerging metaverse technologies, like mixed reality, extended reality (XR), WebXR, and Apple Vision Pro, are growing quickly in addition to conventional AR and VR technology. These technologies represent the further evolution and optimisation of AR and VR technologies, which have brought certain benefits in terms of efficient use in healthcare, education and tourism [5, 28]. Specifically, offering virtual tours through the WebXR metaverse platform can encourage visitors to establish a strong connection with the tourist attraction beyond geographical boundaries [29]. In addition, since the Apple Vision Pro was introduced recently, a number of businesses have released virtual travel apps designed for the device, enabling user to engage in fully immersive virtual travel as well as project real-world objects and people into the virtual world.

In the context of travel, AR devices can improve smart travel services by offering high-quality digital content that raises satisfaction levels and fosters positive emotions [30, 31]. Especially in the scenario of heritage tourism, the application of AR technology can present cultural and indigenous history, natural resource stories, and historic infrastructure in a richer and more realistic way, facilitating visitors' understanding of cultural concepts, which is helpful in both the tour experience and cultural education [32, 33]. AR offers tourists the opportunity to explore virtual augmented world, enabling a more realistic and accurate understanding of cultural heritage sites, which in turn expands their historical knowledge and social consciousness [34]. Visitors gain cultural knowledge from the museum, and AR improves their perceptions. In addition, AR captures their attention and triggers a more positive attitude towards the visit by increasing reflection and inspiration [35]. To encourage visitors to use AR technology in heritage museums, it is necessary to understand the factors that influence visitors' intention.

Socio-technical approach perspectives

The socio-technical systems approach is currently used to study the complex implementation process of information systems [36, 37]. Socio-technical systems approach highlights the interconnectedness of technology and society and considers both social and technical aspects in the design and implementation of a technology [38, 39]. According to this approach, social factors (e.g. people and organizations) and technical factors (e.g. technology and machines) are interlinked and jointly optimized, which enables users to tame new technologies well to fit their unique application environment [40, 41].

There have been previous studies using socio-technical methods to explore consumer behavior. For example, Dong et al. [42] explored the mechanisms of different influences on consumers' purchase intention in livestream shopping from a socio-technical perspective. Based on attachment theory and a socio-technical approach, Li found in [43] that technical factors (synchronicity and alternative expressions) and social factors (interaction and identification) each increase user stickiness through certain mediators. Hu et al. [44] explored the impact of peer membership characteristics (social factors) and technical features of social shopping sites on consumers' purchase intentions. In terms of the adoption of new technologies, Yu et al. [45] used socio-technical systems theory as a theoretical

Table 1 Studies focusing on the use of metaverse technology in tourism

Reference	Research topics	Theoretical foundation	Key findings
[50]	Introduced the concept of Second chance tourism (SCT)		Define the application of mixed reality to special destinations as Second chance tourism The expansion of mixed reality applications in the context of cultural tourism allows this form of SCT to offer visitors the opportunity to go beyond the physical destination
[5]	Relationship among MR functional elements, immersive experience and post-experience behaviors	Technological requirements theory Technology acceptance model (TAM) Technology readiness and acceptance model (TRAM)	Interaction has a positive impact on the traditional experience (items: heritage valorisation and educational) and thus on post-experience behaviors Interaction has a positive impact on 4.0 experience (items: entertainment, socialisation and escape)
[17]	Cross-cultural differences in AR acceptance	Motivational theory Cross-cultural approach on IT acceptance	AR aesthetics has a positive impact on perceived usefulness, perceived ease of use, perceived enjoyment, and social influence Perceived usefulness, perceived ease of use, perceived enjoyment, and social influence have positive impact influences on AR behavior intentions
[51]	Relationship among consumers' beliefs about AR, AR satisfaction and behavior intentions	Post-acceptance model of information systems (IS) continuance Balance theory Theory of reasoned action (TRA)	Expectation confirmation has a positive impact on perceived advantage, aesthetic experience and perceived enjoyment Perceived advantage and aesthetic experience have positive influences on AR satisfaction AR satisfaction has a positive impact on attitudes toward a destination (cognitive and affective)
[16]	Three factors that encourage visitors to use AR	Technology readiness and acceptance model Structural equation model	Technology readiness affects the model through two dimensions, Optimism and Innovativeness Personal factor (Technology Readiness), stimulus factor (Visual Appeal) and situational factor (Facilitating Conditions) have positive influences on AR technology perception
[52]	Relationship among experience, offline museum visit intention and the four realms of the experience economy	Experience economy model Behaviorattitudinal theory	Absorptive (education and entertainment) experiences have positive influences on immersive (escapism and esthetic) experiences The four realms of the experience economy have positive influences on overall VR Museum experience
[53]	Relationship between the type of information, immersive scenes and the evaluation of the visitor experience and their subsequent purchase intentions		Dynamic verbal cues have a positive main effect on visitors' willingness to pay more High virtual presence significantly contribute to the main effect of dynamic verbal cues on visitors' willingness to pay more
[19]	Influencing factors on user satisfaction with AR applications and the behavior intention to recommend	Process theory	AR content quality, AR system quality and AR personalized service quality have positive influences on AR satisfaction and personal innovativeness has a significant moderating effect Intention to recommendation is significantly affected by AR satisfaction

foundation to help us understand the antecedents and consequences of AI adoption and application in the workplace. Correspondingly, we can explore the use of AR technology in tourism from a socio-technical systems perspective to examine the impact of social and technological factors.

From the socio-technical perspectives, we consider that users' behavior intention and satisfaction can be affected by three factors, which are technical, individual and situational. In previous studies, the technical factors have often been part of a socio-technical approach perspective that emphasizes the role of technology in practice, mediating and directing activities in complex systems [46]. The individual factors were proposed by Parasuraman, Colby [47], which were considered to have strong explanatory power for the acceptance of AR. In [48], the author introduced situational factors, which are often used to explain users' behavior when confronted with a particular physical or social environment. In addition, Zhu et al. [49] stated that both individual and situational factors can determine user effectiveness and have persuasive influences on users' attitudes. In this study, we subsume individual and situational factors into the social perspective to explore the key indicators that impact users' behavior intention after experiencing AR devices from a socio-technical approach perspective.

Theoretical framework and hypotheses development

Research model

In our model, satisfaction is used as a mediating structure in the causal chain between the characteristic properties of AR and post-use behavioral benefits. Thus, our model highlights three basic factors from a socio-technical perspective (technical, individual, and situational) that influence the users' behavior, the relationship formation process (the formation of satisfaction), and the outcome (intention afterwards). The model demonstrates an understanding of the features of AR that influence users' post-use behavior intention through satisfaction. Our research model is shown in Fig. 1.

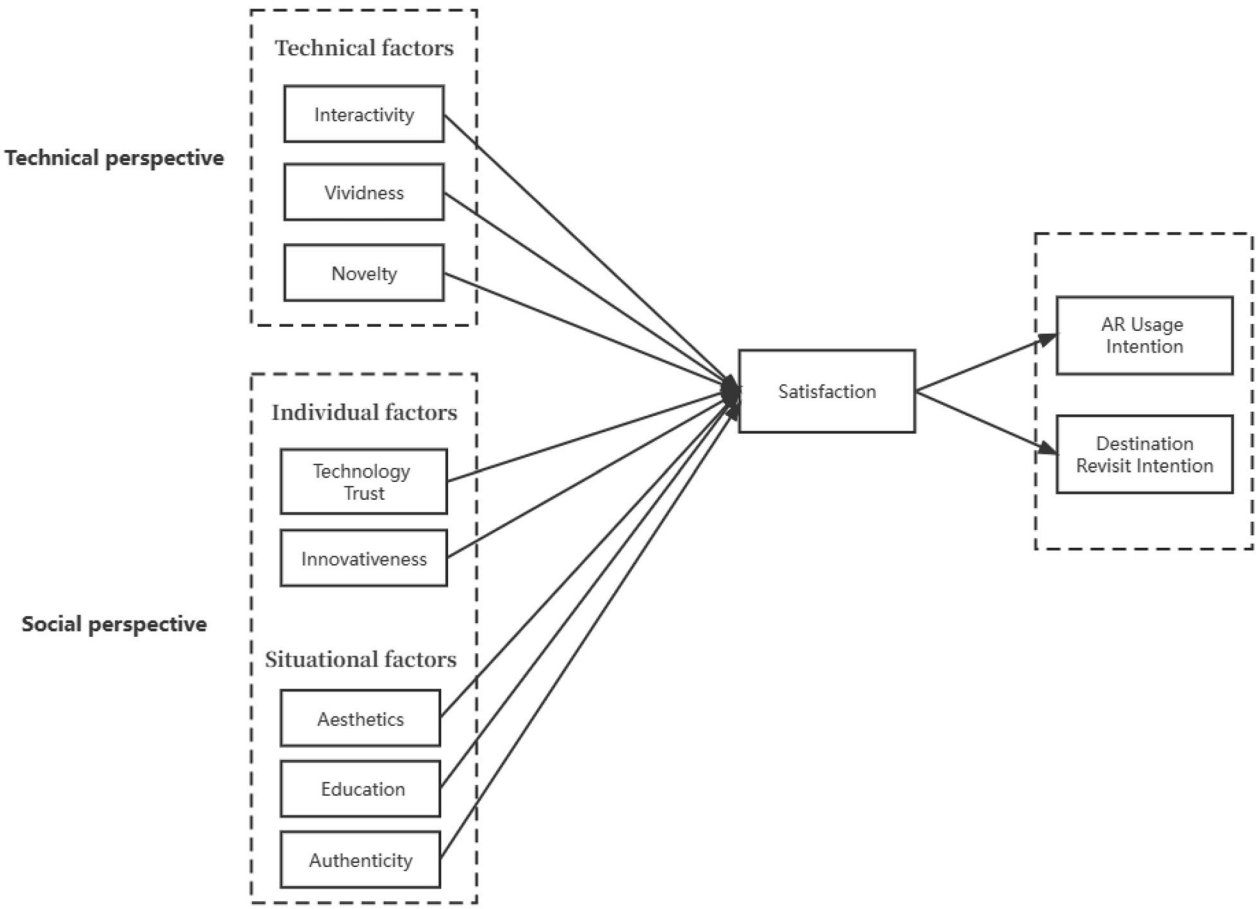

Fig. 1 Research model

Hypotheses development

Technical factors

Most human activities contain an element of interactivity. The essence of augmented reality is the manipulation of digital content that combines the real world with the virtual world [54]. In this environment, interactivity represents the extent to which users can participate in using and modifying the form and content of the digital environment [55]. There are two roles for interactivity in the effective implementation of AR: (1) as a technical outcome and (2) as a user perception [56]. In this study, we classify interactivity as a technical factor, focusing on its role as a technical outcome. Scholars who stress the importance of technological features define interactivity as a property of the technology employed. Technology allows users to improve their ability to adjust and engage with content [57]. Therefore, interactivity, which is part of the unique attributes of AR, is an important factor in how digital technology affects the perception of users' experience [13].

Heritage museums are information-intensive institutions. This interaction in an immersive environment provides a richer dynamic experience for visitors and often acts as an influencing factor on users' behavior intention through different mediators [5, 15]. Previous research shows that a high level of interaction with digital technology has a positive impact on users' satisfaction [54, 58]. In the context of the heritage museum, AR implementation in the exhibition gallery provides additional information about the artefacts at the heritage site through text, audio, video and interactive games that are captured by visitors during the tour [59]. AR can improve tourists' relationships with their environment by using 360-degree footage, resulting in a higher level of immersion [60]. AR technology brings static collections to life, transforming the user experience from touring a static collection to input interaction with virtual objects [61]. Interaction brings the virtual presence as close to the real presence of the visitor as possible, enabling visitors to focus on the interaction between the individual and the artwork, thereby increasing visitor satisfaction [24, 60]. Based on the above discussion, we make the following hypothesis:

H1: The interactivity of AR in heritage museums has a positive impact on users' usage satisfaction.

In previous research, vividness was the way through which the environment presents information to the senses and had also been defined as a technical characteristic depending on the medium [62]. Vividness is the process of combining visual experience with non-sensory imaginary objects in one's mind, enabling one to conceive an image of the product clearly [54]. From a technical perspective, vividness can improve the quality of information and create more multisensory online experiences by providing richer formats [63]. Our study uses vividness to explain the high virtual presence of visual impact presented by augmented reality devices.

Vivid information in the digital environment includes audio, images and other visual contents. These dynamic visual content facilitate the generation of mental images that evoke a good experience for users [53, 64]. The vividness of metaverse technology often enhances positive feelings by increasing visitors' sense of presence [65]. In the museum situation, He et al. [53] argued that when AR provides a high virtual presence, the image of vividness and the value of the users' experience form a crosstalk mediating effect. Vivid images with high pixel counts are favorable to visitors' perceptions and make them have good usage experience [53]. Based on the above discussion, we make the following hypothesis:

H2: The vividness of AR in heritage museums has a positive impact on users' usage satisfaction.

Novelty is the process of experiencing something different from what is normally encountered and is often defined as the degree of difference in an individual's response to a stimulus [66]. Nevertheless, in tourism, novelty is the extent to which the experience deviates from personal expectations. It provides unexpected excitement and enjoyment to visitors and is an essential concept for understanding consumer behavior and motivation for travel [67].

In an augmented reality environment, novel information can capture users' attention and curiosity, leading to a tendency to focus [54]. McLean and Wilson (2019) argued that when using AR devices, the range of real and virtual worlds available for manipulation changes with users' state each time. Users can experience different stimuli every time. Using AR to visit museums, users can enjoy the objects of the past in reality across the limitations of time and space, and experience the cultural content in a new way [68]. This method needs to be able to influence the emotional response of visitors and trigger their interest, thus enhancing their memory of the event and usage satisfaction [67]. Based on the above discussion, we make the following hypothesis:

H3: The novelty of AR in heritage museums has a positive impact on users' usage satisfaction.

Individual factors

Technical support factors can have a great impact on subsequent users' usage when new technology is put into use. However, from the social perspective, individual differences in users, such as personal habits and personality traits, can predict user attitudes and behavior [69–71]. We considered two individual factors, technology trust and innovativeness of users in the context of heritage museum AR applications.

Trust helps to alleviate the uncertainty associated with the adoption of new technologies and technological advances, and is a major factor related to user acceptance [72]. In the field of e-commerce, trust is the degree to which an online service provider is understood and accepted by consumers when fulfilling their transaction obligations [73]. There have been many studies in the e-commerce field that have focused on the relationship between trust and consumer attitude, behavior intention and purchase determination [74, 75]. As for the tourism field, studies have evaluated the role of trust in online service platforms and service bots [76–78]. In technology-oriented research, trust in technical service has three components: reliability, functionality and helpfulness [79].

In the area of AR technology applications, Kang, Kim, et al. [80] empirically verified the positive impact of user trust in mobile augmented reality applications on users' intentions. In the scenario of usage in heritage museums, as individuals' trust in AR technology increases, their trust in the reliability, functionality, and helpfulness of the technology also increases accordingly [81]. On the reliability dimension, trust leads users to believe that the AR technology is capable of meeting their expectation that the device will work consistently and stably without any failure. On the functionality dimension, users believe that the AR device is capable of carrying out the tasks they request. On the helpfulness dimension, the technology is perceived to be able to provide sufficiently responsive help to users with its specific assistive experience features. These three dimensions allow users to engage with the technology in an immersive way, without being distracted by their doubts and hesitations. We thus think that the technology trust (reliability, functionality and usefulness) triggered by the use of AR technology in the heritage museums scenario can have an impact on satisfaction. Based on the above discussion, we make the following hypothesis:

H4: Users' technology trust in AR has a positive impact on users' usage satisfaction.

Parasuraman [82] defined technology readiness as the tendency of people using new technologies to achieve certain goals. Technology readiness shifts the focus from the technology itself to users, identifying their individual differences and understanding their psychological intention in accepting the technology [83]. Previous researchers often use innovativeness as one of the progressive technology readiness factors to investigate the acceptance of new technologies and products [83, 84]. Innovativeness can reflect the probability of a person's willingness to use a new technology [72]. In previous studies, Jiang et al. [85] empirically examined the impact of this theory's five innovation features through the mediation of consumer attitudes. Faqih [14] investigated the mechanisms by which perceived innovations influence users' behavior and intention to adopt mobile augmented reality games.

Moreover, in the tourism industry, Chung et al. [16] examined innovativeness as part of technology readiness, arguing that innovativeness is an enabler for users to use AR technology. Innovative users have high levels of curiosity, and believe they are capable of using new technologies well and dealing with technological uncertainty on their own [86]. Museum visitors who possess the personality trait of higher innovativeness have a tendency to make decisions about adopting new technologies independently of others and thus develop a greater technology affinity [87]. Based on the above discussion, we present the following hypothesis:

H5: Users' innovativeness has a positive impact on users' usage satisfaction.

Situational factors

The social perspective includes not only individual factors, but also situational factors. When examining user behavior, previous research often combines individual and situational factors to explore the factors that drive the actual use of a technology. In the case of a heritage museum scenario, situational factors influence user attitude towards the use of technology during a particular tour itinerary [84, 88]. Augmented reality devices in heritage museums focus more on the extent to the content fits the specific function of the museum than in other areas. The willingness of visitors to use AR devices for tours depends on whether the scenes presented by AR are aesthetically harmonious, how much educational value they provide, and whether the content design is a realistic representation of the collection and location. We employ three situational factors, aesthetics, education and authenticity, to conduct the study.

During a tour of a specific environment like a museum, the enjoyable aesthetic experience requires the individual (the visitor) to autonomously devote his or her attention to the appreciation of art and to form his or her own mental intention for the given artwork [53]. Therefore, in addition to practical functions, designers should also pay attention to the aesthetic role of the tool [89]. AR gives users stimulation related to visual aesthetics and auditory aesthetics by combining the sensory experience of real objects with the non-sensory experience of virtual objects [90, 91]. People have different aesthetic preferences, and it is difficult to satisfy them all. Therefore, the design of AR scenes should harmoniously integrate the beauty of form, colour scheme, etc., and adopt a quantitative method to achieve a higher level of beauty to improve usage satisfaction [89]. In specific situations such as museums, the combination of artistry and fun is

important [52]. We classify such aesthetic factor peculiar to the museum scene as a situational factor, which has a role in influencing the decision-making process and outcome [92, 93]. Based on the above discussion, we make the following hypothesis:

H6: The aesthetics in heritage museums have a positive impact on users' usage satisfaction.

The use of metaverse technologies in specific situations can produce highly emotional and cognitive stimulation in the learning environment, thereby enhancing the learning effectiveness of users [94]. In highly participatory learning tourism situations such as museums, it is important to shift the focus from simply displaying valuable collections to enriching visitors' engagement and improving their edutainment experience [52]. The artefacts at the heritage museum already hold significant educational value. Using metaverse digital tools to extend learning can help learners enhance their cognitive processes and creativity with forms such as motor control and incarnation of the digital world [8, 95]. The rich learning content and immersive environment provided by AR devices can make users feel satisfied. Based on the above discussion, we make the following hypothesis:

H7: The education in heritage museums has a positive impact on users' usage satisfaction.

Authenticity is often divided into two dimensions: existential authenticity and perceived authenticity (experiential authenticity). Existential authenticity refers to the authenticity of the visitor's presence, which suggests that tourists expect the tourism environment and its constituent elements they experience to be authentic [96]. Perceived authenticity is a psychological state that arises from tourists' interactions with exhibits, architecture, events, and other elements at the destination [97, 98].

In the museum context, both natural and man-made degradation of artefacts, as well as economic issues, necessitate a shift in the museum paradigm from being collection-based to being visitor-based [52]. The exhibits of a heritage museum condense the stories and cultures of the past. If visitors can participate in historical scenes that accurately reflect the past, then the experience can satisfy both dimensions of authenticity. This can positively influence their post-experience behavioral intention and increase the attractiveness of the museum [99]. According to [51], the use of a new technology enables the combination of the authenticity experience of exhibits with the inauthentic experience of the digital world, allowing visitors to transcend spatial and temporal constraints and language barrier [52]. Empirical studies have shown that authenticity positively influences visitors' satisfaction and loyalty to the experience perception and heritage values [100, 101]. Therefore, using AR technology to make authentic scenarios is crucial to influencing usage satisfaction, destination choice, and post-use activity [102]. Based on the above discussion, we make the following hypothesis:

H8: The authenticity in heritage museums has a positive impact on users' usage satisfaction.

Satisfaction and post-experience behavior intention

The psychological processes behind satisfaction are complex. Research has shown that most of the literature on satisfaction variables has examined them in three categories: satisfaction as a process to analyse the context or elements of its formation, satisfaction as an answer to study its conceptual nature and origins, and satisfaction combined with cognitive-emotional approaches to compare [103]. Our study adopts the first approach by considering satisfaction as an intermediate link and process and examining its influencing factors and subsequent influence on the two behavior intentions.

Satisfaction is a key factor in measuring the effectiveness as well as the success of an information system [104]. The sense of experience and attitude towards a system can influence the subsequent behavior intention of users [5, 16]. In previous research, satisfaction is a strong predictor of users' continuous intention to use a system or technology [105]. Jiang et al. [106] argued that using an AR tour brings positive feedback and satisfaction with the AR device, which positively affects users' usage intention. Therefore, the positive feelings of AR users towards the device lead to the intention to use AR [16]. Visitors' travel intention towards the destination is also one of the factors influencing post-experience travel outcomes [16, 107]. The positive attitudes towards the heritage museum formed through the AR device would induce visitors to generate a willingness to revisit. Based on the above discussion, we make the following hypotheses:

H9: Users' usage satisfaction has a positive impact on the AR usage intention.

H10: Users' usage satisfaction has a positive impact on the destination revisit intention.

Methods

Study site

The study took place in the Liangzhu Museum in Liangzhu Site Park, Hangzhou City. The Liangzhu Museum is the main preservation and exhibition center of the Neolithic Liangzhu civilization, which is located in the core area of the Liangzhu civilization, at the junction of the hilly mountains of western Zhejiang and the plains of northern Zhejiang [108]. It has been included on the World Heritage List since 2019 and is rich in archaeological and heritage value for visitors [109]. Visitors to the museum can experience heritage tours, cultural experiences, map navigation, digital sandbox games and other

tourism services. To enhance the visitor experience, Rokid has designed and integrated an augmented reality glasses device. In the showroom, visitors can use the device to watch and interact with 3D animations directly related to the exhibits or Liangzhu culture by following the tour route. The glasses device enables computer-generated virtual objects to enhance the real-world tour experience, giving visitors a better sense of tour satisfaction.

Measurements

Based on the previous literature studies, we adopted the following 11 measurement items: interactivity [5, 56], vividness [56], novelty [13], technology trust [72], innovativeness [16], aesthetics [51], education [52], authenticity [101], satisfaction [19, 110], AR usage intention [105, 106], and destination revisit intention [51, 111].

This procedure yielded 36 measurement items, which are summarized in Appendix by each construct. These items were written in English, so they were first translated into Chinese and then back-translated into English. To ensure the accuracy of the translation, we invited several professors to review the scales and modified the scales based on their feedback. All items were measured on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Furthermore, the questionnaire collected statistical information on the respondents' gender, age, education, occupation, and whether they had used AR-related devices before.

Data collection

The data was collected from visitors who used the AR glasses between March and April 2022 at the Liangzhu Museum. We gave the users who participated in filling out the questionnaire RMB 5 Yuan each. Considering that some visitors were not aware of the AR device, we introduced to them the general principles of AR and how to use the device before the experience. Visitors were asked to fill out the questionnaire after using the glasses for at least one hour to visit the three pavilions containing the AR experience. A random sample was used in this study to represent the opinions of a general population. After excluding the questionnaires that took less than one minute to answer and those with mostly the same content, we recovered a total of 254 valid questionnaires. The following Table 2 summarizes the characteristics of the respondents. Out of the 254 respondents, 128 (50.4%) were female and 146 (48.6%) were male. The majority of respondents were between the ages of 18 and 30 (69.7%). The number of respondents with higher education (bachelor's degree and above) in this survey was 194 (76.4%). Thus more than half of the respondents had used AR-related devices before (64.2%). We presented the specific questionnaire data in Additional file 1.

Analysis and results

Common method bias

Considering that the data were collected from the same respondents, a common method bias (CMB) problem might arise. So we use the Harman single-factor test to evaluate the potential for CMB. The results show that the variance of the first factor is 35.134%, less than 50%. In addition, the variance inflation factor (VIF) variables ranged from 1.318 to 2.198, below the suggested

Table 2 Respondents' demographic profile (N = 254)

Variable	Category	Frequency	Percentage (%)
Gender	Male	126	49.6
	Female	128	50.4
Age	Under 18	12	4.7
	18–25	129	50.8
	25–30	48	18.9
	30–40	40	15.7
	40–50	19	7.5
	Over 50	6	2.4
Education attained	High school and below	28	11.0
	Junior College degree	32	12.6
	Bachelor's degree	163	64.2
	Master's degree and above	31	12.2
Previous AR device usage (Yes/No)	Yes	163	64.2
	No	91	35.8

threshold of 3.3 for the full covariance test [112]. The current data indicate that there are no common method bias issues.

Measurement model

The measurement model was examined to assess the reliability, convergent validity, and discriminant validity of key constructs. As Table 3 shows, all constructs' composite reliability values exceed the recommended threshold of 0.7 and the Cronbach's Alpha values (0.701–0.807) are all at an acceptable level, having good internal consistent reliability. The lowest value of average variance extracted (AVE) for all metrics was checked to be 0.572, which is higher than the recommended threshold of 0.5 [113]. Moreover, all the factor loadings are above the benchmark value of 0.7 [114]. We also examined the discriminant and convergent validity of each indicator. The results presented in Tables 4, 5, and 6 demonstrate adequate discriminant validity.

Table 3 Results of reliability and convergent validity analysis

Construct	Item	Factor loading	AVE	Composite Reliability	Cronbach's Alpha
Interactivity	INT1	0.740	0.572	0.774	0.755
	INT2	0.741			
	INT3	0.800			
	INT4	0.743			
Vividness	VIV1	0.773	0.626	0.703	0.701
	VIV2	0.783			
	VIV3	0.818			
Novelty	NOV1	0.805	0.655	0.741	0.737
	NOV2	0.793			
	NOV3	0.829			
Technology trust	TT1	0.820	0.717	0.808	0.803
	TT2	0.838			
	TT3	0.880			
Innovativeness	INN1	0.766	0.582	0.772	0.763
	INN2	0.732			
	INN3	0.770			
	INN4	0.783			
Aesthetics	AES1	0.784	0.652	0.747	0.736
	AES2	0.806			
	AES3	0.832			
Education	EDU1	0.841	0.650	0.734	0.731
	EDU2	0.787			
	EDU3	0.790			
Authenticity	AUT1	0.783	0.577	0.765	0.757
	AUT2	0.716			
	AUT3	0.760			
	AUT4	0.778			
Satisfaction	SAT1	0.841	0.706	0.796	0.793
	SAT2	0.828			
	SAT3	0.852			
AR usage intention	AUI1	0.843	0.721	0.808	0.807
	AUI2	0.858			
	AUI3	0.848			
Destination revisit intention	DRI1	0.804	0.633	0.711	0.710
	DRI2	0.802			
	DRI3	0.780			

Table 4 Results of discriminant validity analysis

	INT	VIV	NOV	TT	INN	AES	EDU	AUT	SAT	DRI	AUI
INT	**0.756**										
VIV	0.568	**0.791**									
NOV	0.496	0.520	**0.809**								
TT	0.444	0.509	0.449	**0.847**							
INN	0.317	0.434	0.340	0.557	**0.763**						
AES	0.470	0.504	0.527	0.537	0.433	**0.808**					
EDU	0.482	0.453	0.549	0.473	0.444	0.632	**0.760**				
AUT	0.419	0.511	0.475	0.433	0.386	0.605	0.661	**0.806**			
SAT	0.426	0.495	0.533	0.514	0.374	0.623	0.599	0.588	**0.840**		
DRI	0.369	0.439	0.503	0.511	0.434	0.549	0.614	0.589	0.648	**0.796**	
AUI	0.435	0.409	0.516	0.538	0.399	0.524	0.545	0.598	0.677	0.667	**0.849**

Diagonal elements (in bold) are the square root of AVEs of constructs

Structural model and hypothesis test

As shown in Fig. 2, the difference between 45.8% and 42.0% was explained by AR usage intention and Destination revisit intention. Moreover, the model explained 52.6% of the differences in satisfaction. Specifically, the novelty was positively correlated with satisfaction ($\beta = 0.139$, $p < 0.05$) and H3 was supported. However, the effect of interactivity ($\beta = -0.011$, $p > 0.05$) and vividness ($\beta = 0.082$, $p > 0.05$) on satisfaction was not significant, so H1 and H2 were not supported. Technology trust was positively correlated with satisfaction ($\beta = 0.152$, $p < 0.05$), while innovativeness was not significant ($\beta = -0.035$, $p > 0.05$), so H4 was supported and H5 was not supposed. For situational factors, aesthetics ($\beta = 0.230$, $p < 0.005$), education ($\beta = 0.182$, $p < 0.05$) and authenticity ($\beta = 0.169$, $p < 0.05$) were all positively correlated with satisfaction, so H6, H7, H8 were all significant. Moreover, satisfaction was significantly correlated with AR usage intention ($\beta = 0.677$, $p < 0.001$) and destination revisit intention ($\beta = 0.648$, $p < 0.001$), so H9 and H10 were both supported. Table 7 shows the results of path coefficients and t-values. We use the PROCESS for SPSS to examine the mediating role of satisfaction in the relationship between influences and participant responses. The results show that all variables with significant path coefficients have a positive impact on post-experience behavior intention through satisfaction as a partial mediator.

Discussion and conclusions

Main findings

This study examines the impact of technical characteristics (interactive, vivid, novel), individual characteristics (technology trust, innovativeness) and situational characteristics (aesthetics, education, authenticity) of museum AR experience on visitor satisfaction and the subsequent impact on AR usage intention and destination revisit intention. The empirical study finds that of the 10 hypotheses, H3, H4, H6, H7, H8, H9, H10 are supported, while H1, H2 and H4 reject the original hypothesis.

From the technical perspective, the study verifies that the novelty of AR services has a positive impact on visitor satisfaction. This finding is consistent with the results of [54] and [90]. This particular novel format of using AR services in a heritage museum contributes to user satisfaction after the experience. However, we find that the effect of interaction and vividness in the technical factors on satisfaction and subsequent behavior intention is not significant. That is not consistent with many previous studies [56, 65, 115].

According to [116], when interactivity is considered a feature of technology, the success of the interactive application depends on the design of the hardware, software or middleware. In heritage museums, the lack of a significant positive impact of interactive features on user satisfaction may be due to the failure of interactive performance to have a strong positive impact on the functional value sought by users [13]. There are limitations in controlling and modifying the content by the user when using a metaverse device that has been set up [117]. Such limited interactivity may not satisfy users' needs for functionality while touring. For example, users are not able to accurately and proficiently modify the form and content of the mediated environment, and are required to use the device in an uncomfortable position [118]. On the other hand, when users use this unfamiliar AR device to access site information, they may perceive the effectiveness and efficiency as low, and the increased human–computer interaction does not save time [24, 56]. These reasons reduce the effectiveness of users' interaction and thus fail

Table 5 Cross Loadings of latent variables

	INT	VIV	NOV	TT	INN	AES	EDU	AUT	SAT	DRI	AUI
INT1	**0.740**	0.387	0.392	0.357	0.267	0.378	0.344	0.292	0.282	0.265	0.259
INT2	**0.741**	0.447	0.363	0.329	0.286	0.324	0.358	0.327	0.252	0.298	0.320
INT3	**0.800**	0.451	0.373	0.339	0.213	0.383	0.393	0.341	0.406	0.292	0.354
INT4	**0.743**	0.437	0.380	0.325	0.218	0.332	0.360	0.307	0.315	0.267	0.374
VIV1	0.538	**0.773**	0.426	0.422	0.303	0.386	0.373	0.403	0.371	0.303	0.302
VIV2	0.421	**0.783**	0.345	0.418	0.364	0.349	0.324	0.410	0.398	0.378	0.326
VIV3	0.398	**0.818**	0.465	0.370	0.362	0.461	0.380	0.400	0.406	0.359	0.341
NOV1	0.361	0.387	**0.805**	0.385	0.251	0.427	0.448	0.344	0.430	0.379	0.374
NOV2	0.412	0.421	**0.793**	0.334	0.259	0.403	0.392	0.354	0.396	0.434	0.416
NOV3	0.430	0.453	**0.829**	0.368	0.312	0.447	0.487	0.450	0.464	0.410	0.461
TT1	0.394	0.443	0.413	**0.820**	0.398	0.518	0.387	0.391	0.475	0.430	0.486
TT2	0.323	0.427	0.381	**0.838**	0.484	0.424	0.390	0.316	0.381	0.406	0.385
TT3	0.400	0.419	0.341	**0.880**	0.540	0.410	0.422	0.385	0.437	0.458	0.482
INN1	0.766	0.272	0.190	0.527	**0.766**	0.305	0.316	0.249	0.271	0.314	0.290
INN2	0.732	0.311	0.241	0.346	**0.732**	0.232	0.315	0.233	0.228	0.280	0.285
INN3	0.770	0.370	0.320	0.405	**0.770**	0.337	0.378	0.354	0.288	0.347	0.304
INN4	0.783	0.364	0.279	0.417	**0.783**	0.415	0.342	0.326	0.336	0.368	0.334
AES1	0.370	0.388	0.398	0.479	0.370	**0.784**	0.528	0.463	0.450	0.425	0.411
AES2	0.358	0.436	0.453	0.428	0.358	**0.806**	0.543	0.511	0.467	0.412	0.430
AES3	0.329	0.402	0.427	0.405	0.329	**0.832**	0.474	0.494	0.576	0.485	0.430
EDU1	0.342	0.429	0.395	0.338	0.342	0.507	**0.552**	0.841	0.506	0.505	0.494
EDU2	0.301	0.430	0.457	0.333	0.301	0.483	**0.509**	0.787	0.449	0.439	0.452
EDU3	0.289	0.377	0.301	0.379	0.289	0.474	**0.537**	0.790	0.466	0.479	0.501
AUT1	0.413	0.349	0.414	0.361	0.367	0.492	0.783	**0.526**	0.472	0.509	0.416
AUT2	0.336	0.368	0.391	0.316	0.309	0.484	0.716	**0.453**	0.361	0.418	0.375
AUT3	0.387	0.340	0.462	0.353	0.323	0.461	0.760	**0.476**	0.454	0.457	0.395
AUT4	0.331	0.331	0.405	0.398	0.345	0.491	0.778	**0.544**	0.512	0.474	0.462
SAT1	0.282	0.362	0.395	0.481	0.340	0.506	0.475	0.397	**0.841**	0.543	0.536
SAT2	0.385	0.420	0.481	0.383	0.285	0.485	0.509	0.500	**0.828**	0.498	0.544
SAT3	0.402	0.461	0.467	0.432	0.318	0.573	0.525	0.576	**0.852**	0.587	0.620
DRI1	0.306	0.346	0.379	0.445	0.314	0.408	0.488	0.441	0.532	**0.804**	0.512
DRI2	0.315	0.310	0.386	0.430	0.393	0.445	0.466	0.411	0.483	**0.802**	0.499
DRI3	0.262	0.388	0.434	0.347	0.332	0.457	0.508	0.549	0.528	**0.780**	0.577
AUI1	0.427	0.364	0.466	0.442	0.302	0.487	0.452	0.510	0.587	0.598	**0.843**
AUI2	0.342	0.330	0.422	0.473	0.380	0.446	0.444	0.505	0.545	0.525	**0.858**
AUI3	0.338	0.346	0.425	0.457	0.338	0.402	0.492	0.508	0.590	0.572	**0.848**

Diagonal elements (in bold) are the factor loadings of constructs

to have a positive positive impact on promoting satisfaction and post-experience behavior intention.

In addition, although the interactivity and vividness of the virtual presence affect users' immersive experience, familiarity to the technology reduces the positive impact of interactivity and vividness on users' responses [56]. Many users have been previously exposed to many AR devices used in other domains, so these two factors do not have a significant impact on usage satisfaction and post-experience behavior intention. However, there are few augmented reality devices put into use in heritage museums in China, so the use of AR in this field is still novel to visitors. The dynamic view content displayed by the Liangzhu Museum's AR device is not comprehensive and informative enough, and the visual impact is weak. This leads to a relatively low presence of virtual presence experienced by users, which also affects the fulfilment of the experience value. Therefore, interactivity and vividness are not the key features to enhance users' satisfaction (Additional file 1).

From the individual perspective, the study verifies that the technology trust of AR services has a positive

Table 6 Heterotrait-monotrait (HTMT) ratio

	INT	VIV	NOV	TT	INN	AES	EDU	AUT	SAT	DRI	AUI
INT											
VIV	0.783										
NOV	0.665	0.723									
TT	0.566	0.677	0.580								
INN	0.431	0.587	0.447	0.711							
AES	0.631	0.702	0.714	0.698	0.566						
EDU	0.562	0.714	0.646	0.562	0.508	0.825					
AUT	0.635	0.626	0.732	0.601	0.579	0.855	0.882				
SAT	0.531	0.661	0.694	0.639	0.472	0.803	0.766	0.762			
DRI	0.505	0.618	0.696	0.675	0.584	0.754	0.882	0.831	0.858		
AUI	0.550	0.542	0.667	0.662	0.506	0.680	0.778	0.692	0.842	0.877	

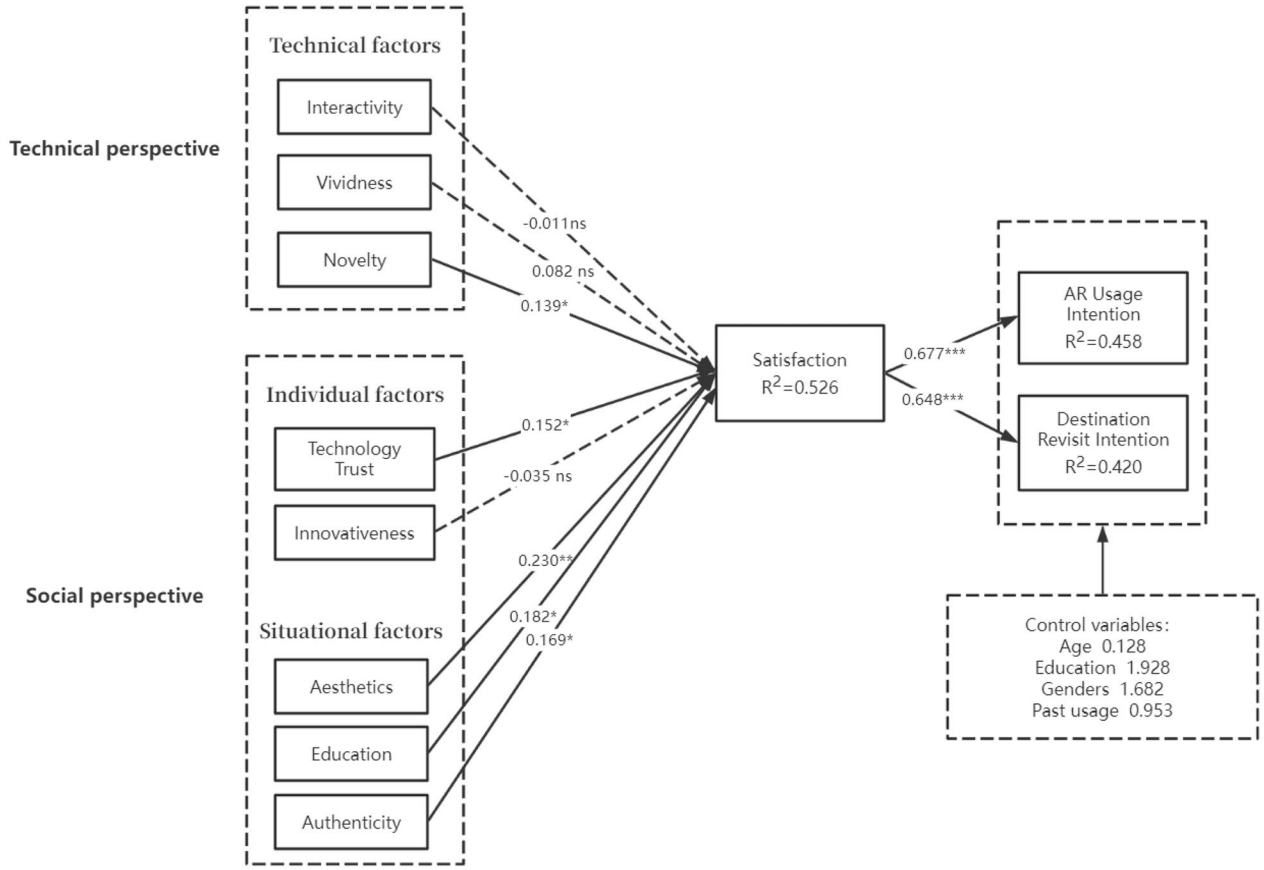

Fig. 2 Structural equation model analysis results. Note(s): *p < 0.05; **p < 0.01; ***p < 0.001; ns = non-significant

impact on satisfaction. The results are in line with previous studies on the factors influencing the application of new technologies and systems [75, 119]. However, differently from previous studies, we did not find a significant positive impact of innovativeness on usage satisfaction. This may be due to the widespread use of AR technology in various fields over the last decade, making the device less challenging for users. Highly innovative individuals have a relatively high tendency to adopt new technologies, and they are more prone to demand that the new technologies they use are well-established and high-performance

Table 7 Path coefficients and t-values (N = 254)

Hypothesis	Path	Path coefficient (β)	T value	Support
H1	INT → SAT	− 0.011 ns	0.176	No
H2	VIV → SAT	0.082 ns	1.110	No
H3	NOV → SAT	0.139*	2.143	Yes
H4	TT → SAT	0.152*	2.257	Yes
H5	INN → SAT	− 0.035 ns	0.549	No
H6	AES → SAT	0.230**	3.123	Yes
H7	EDU → SAT	0.182*	1.961	Yes
H8	AUT → SAT	0.169*	1.985	Yes
H9	SAT → AUI	0.677***	16.144	Yes
H10	SAT → DRI	0.648***	16.375	Yes

* p < 0.05, ** p < 0.01, *** p < 0.001, ns = non-significant

[120]. Therefore, another possible reason is that the design and application of the device in the heritage museums is not sufficiently functional and it is limited to the internal artefacts. This low performance of the site's activities may be the reason why personal innovativeness negatively affects the users' satisfaction. It shows that individual innovativeness is not a determining factor in satisfaction.

From the situational perspective, all three independent variables (aesthetics, education, and authenticity) are important in influencing visitor satisfaction and post-experience behavior intention, and aesthetics was highly significant. It indicates that in specific contexts such as heritage museums, AR devices are more focused on information delivery and aesthetic fit [18, 121]. Aesthetics of the scenario, achieved through the visualisation elements, are successful in meeting the aesthetic needs of visitors to the museum and making them feel comfortable [51, 53]. Additionally, the support of education, authenticity on satisfaction in this study is consistent with previous research [52, 100].

Theoretical implications

This study has the following theoretical implications. Firstly, our study is one of a small number of studies on the application of AR to the field of heritage museums. Most studies of augmented reality in museums analyse the impact of perceived value, perceived ease of use and perceived usefulness as well as specific technical and psychological intention factors on user behavior, but few studies empirically investigate the factors that influence usage satisfaction and behavior intention from a comprehensive perspective [6, 16, 17, 53]. Our study theoretically enriches the explanation of the antecedents of users' usage satisfaction.

Secondly, our study applies a socio-technical approach perspective to construct a theoretical framework that explores the role of factors from both technical and social perspectives in driving usage satisfaction and behavior intention. Most previous empirical studies use the socio-technical perspective to examine the antecedents of the adoption of new technologies, such as AI, live streaming and new systems, etc. [41, 43, 45, 46]. In contrast, there is little literature on AR technology that examines the antecedents of its adoption from this perspective. As a result, we fill the gap in previous research that only considers social or technical perspectives. Introducing a socio-technical perspective in AR heritage tourism explores the influencing factors of AR adoption based on the actual usage of AR users in museums, which helps to analyse the potential drivers of users' satisfaction.

Thirdly, we break down post-experience behavior intention into two areas: AR usage intention and destination revisit intention. Previous studies set the users' subsequent behavior intention as one variable, focusing on measuring user intention for the corresponding application scenario. However, the utilization of IT technology can affect not only the visitors' experience of the destination, but also their attitude towards this technology. Our study comprehensively measures the intentions of individuals who experience AR at this museum about subsequent use of AR and intentions to revisit the heritage destination, enriching the mechanisms of how usage satisfaction plays a role in the development of subsequent users' actions.

Practical implications

This study provides some useful guidance for both heritage museums and AR technology providers. Currently, immersive tourism is mostly geared towards metaverse exhibitions and theme parks, while it is less developed in tourism categories such as cultural tourism. At the same time, China's long-standing culture makes many heritage museums worth visiting, but most of them are too old-fashioned and not innovative in the way they are visited. Therefore, for heritage museums, integrating immersive technology into tours can help the rapid recovery of museum tourism after the epidemic, meet the diverse needs of tourists and increase visitor satisfaction as well as interest in heritage museums. In addition, the digital presentation of artefacts is extremely important in terms of cultural research and cultural preservation [122]. Before using digital technologies in museums, the cultural resources of the museums may not be fully digitised and stored. Therefore, obtaining highly accurate digital images of heritage pieces is a current task that needs to be done by heritage museums.

For AR technology providers, the results of this study can be used as practical insights for developing and operating AR applications. The results of the study

show that the novelty of AR technology as well as the aesthetic, education and authenticity attributes of the actual application in the museum settings are closely related to generating positive visitor attitudes. Therefore, AR technology providers should improve the quality of information and aesthetic harmony of the content provided to users in the AR medium in the current heritage museum situation. At the same time, it is extremely important to create a high level of interactivity and vividness in the technical features of the medium that are not affected by users' technological familiarity [56]. In addition, AR technology providers should also focus on the stability and ease of use of the device, providing users with a comfortable and immersive experience to increase their trust in the technology.

The results of this study and previous research reveal that experiencing cultural heritage resources in an immersive way with the aid of metaverse interactive devices is a new way of tourism that contributes to the experience. A necessary process for such a tour is the digitization of cultural heritage sites. Metaverse-oriented digitization of cultural heritage is a new and much-needed aspect of the task of heritage development and conservation [122]. Experiencing cultural heritage site tourism in such a scenario integrates more real-world experiences and expands the audience of visitors in a more educationally oriented form. Therefore, heritage museums and AR technology providers should focus more attention on how to use IT to achieve a win–win situation for both heritage conservation and visitor experience.

Limitation and future research

Although metaverse technologies are widely used and exhibit promising future developments, it is crucial to contemplate their possible negative effects. Future studies should look into the risks that consumers' excessive usage of metaverse technologies poses to their physical, psychological, and privacy [123]. Furthermore, the expensive cost of hardware required for high-end metaverse devices and the restricted cross-device interoperability of hardware with metaverse platforms have had an impact on the widespread use of the technology [124]. As a result, further in-depth study into the components of various metaverse-related technologies is still needed.

There are some limitations to this study. Firstly, the respondents of this study are limited to AR glasses users at the Liangzhu Heritage Museum, and the empirical results are limited. In future studies, we should expand the range of respondents and investigate more relevant data from other cultural heritage sites. Secondly, the dependent variables considered in the current study are summarized from the previous literature and do not capture all the influencing factors. Subsequent research can gather some of the variables that are easily overlooked through interviews with developers, museums and experiential visitors.

Appendix

Constructs	Items	Source
Interactivity	1.When using the AR glasses, I can stay in each step at my own pace	Yim et al. [56] Trunfio et al. [5]
	2.When using the AR glasses, I can visit back and forth easily during the process	
	3.When using the AR glasses, I can increase interaction with the multimedia elements	
	4. When using the AR glasses, it responded correspondingly to the requests I entered	
Vividness	1. AR glasses make my tour experience clear	Yim et al. [56]
	2. AR glasses make my tour experience detailed	
	3. AR glasses make my tour experience vivid	
Novelty	1. Using augmented reality devices in cultural tourism offers something new each time	Nikhashemi et al. [13]
	2. Using augmented reality devices in cultural tourism offers something different each time	
	3. Using augmented reality devices in cultural tourism offers special content	
Technology trust	1. I think that this AR would not fail me	Meyer-Waarden [72]
	2. I think that this AR would provide 100% reliable services	
	3. I would totally trust this AR	

Constructs	Items	Source
Innovativeness	1. In general, I am among the first in my circle of friends to acquire new technology when it appears	Chung et al. [16]
	2. I can usually use new high-tech products and services without help from others	
	3. I can keep up with the latest technological developments in my areas of interest	
	4. I have fewer problems than others in making technology work for me compared to others	
Aesthetics	1. The overall design and content of the picture are not bland	Chung et al. [51]
	2. The setting presented by AR focuses on the harmony of design details	
	3. In general, the functions/features of the AR device can fully meet users' aesthetics needs	
Education	1. The content presented by AR conveyed a lot of new knowledge about the culture of the site	Lee et al. [52]
	2. The knowledge presented by AR was rich and complete	
	3. The use of AR technology in that scenario could stimulate users' learning curiosity	
Authenticity	1. The overall exhibits reflected actual situation of the past	Park et al. [101]
	2. This visit provided information on ancestors and their daily life, on the phases of the past, and on traditional cultures	
	3. This visit provided users with the opportunity to experience life in the past	
	4. This visit provided insight into the historical era	
Usage satisfaction	1. I was satisfied with the contents of the AR device	Jung et al. [19] Chen et al. [110]
	2. I was satisfied with the functions of the AR device	
	3.Totally, I was satisfied with the use of AR device in this heritage museum	
AR Usage Intention	1. I plan to continue to use the device's augmented reality features for museum visits instead of stop using them	Kim et al. [105] Jiang et al. [106]
	2. I want to use device's augmented reality features for future museum visits	
	3. I highly recommend that others use the device's augmented reality features to visit the museum	
Destination Revisit Intention	1. I intend to visit the destination again sometime	Stylos et al. [111] Chung et al. [51]
	2. I'd love to come to visit the destination again	
	3. I want to recommend the destination to others	

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40494-024-01217-1.

Additional file 1: Questionnaire Data.

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Author contributions
YC and XW conceived the manuscript structure; YC and XW developed the conceptual framework and wrote the draft; XW and BL prepared tables and figures; YC, LW, and BL revised the manuscript; YC, XW, LW, and BL reviewed the manuscript; YC received funding.

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Availability of data and materials
The datasets used and analyzed in the current study are available are available from the corresponding author by reasonable request.

Declarations

Competing interests
The authors declare that they have no competing interests.

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