



Augmented Reality in Tourism: From Immersive App Experiences to Continued Use

Realidad aumentada en turismo: de las experiencias inmersivas en aplicaciones móviles al uso continuado

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Abstract

This study aims to explore tourists' intentions to continue using augmented reality mobile applications in the tourism sector. Grounded in the extended expectation-confirmation theory, a conceptual framework was developed to examine tourists' continuance usage intentions. Data were gathered via an online survey from 343 participants who recently engaged in tourism activities and used augmented reality mobile applications in Pakistan. The proposed model was tested using partial least squares structural equation modelling. The results indicate a significant positive relationship between augmented reality mobile applications, perceived usefulness, satisfaction, and expectation confirmation. While perceived usefulness did not directly influence satisfaction, it demonstrated a significant impact on continuance usage intention. Both confirmation of expectations and satisfaction positively influenced the intention to continue using augmented reality mobile applications. These findings offer valuable insights into how to manage tourists' expectations better and improve satisfaction, thereby fostering repeat visits and supporting sustainable tourism development. This study contributes to understanding the factors influencing users' continued use of augmented reality mobile applications in tourism and hospitality contexts.

Keywords: Augmented Reality, Continuance Intention, Satisfaction, Perceived Usefulness, Expectation-Confirmation Theory, Tourism and Hospitality.

Resumen

Este estudio tiene como objetivo explorar la intención de los turistas de seguir utilizando aplicaciones móviles de realidad aumentada en el sector turístico. Con base en la teoría extendida de confirmación de expectativas, se desarrolló un marco conceptual para examinar la intención de uso continuo de los turistas. Los datos se recopilaron mediante una encuesta en línea aplicada a 343 participantes que recientemente realizaron actividades turísticas y utilizaron aplicaciones móviles de realidad aumentada en Pakistán. El modelo propuesto se evaluó mediante el modelado de ecuaciones estructurales con mínimos cuadrados parciales. Los resultados indican una relación positiva y significativa entre las aplicaciones móviles de realidad aumentada, la utilidad percibida, la satisfacción y la confirmación de expectativas. Aunque la utilidad percibida no influyó directamente en la satisfacción, sí tuvo un impacto significativo en la intención de uso continuado. Tanto la confirmación de expectativas como la satisfacción influyeron positivamente en la intención de continuar utilizando aplicaciones móviles de realidad aumentada. Estos hallazgos ofrecen información valiosa sobre cómo gestionar mejor las expectativas de los turistas y aumentar su satisfacción, lo que favorece las visitas repetidas y apoya el desarrollo turístico sostenible. Este estudio contribuye a comprender los factores que inciden en el uso sostenido de aplicaciones móviles de realidad aumentada en contextos turísticos y hoteleros.

Palabras clave: Realidad Aumentada, Intención de Uso Continuado, Satisfacción, Utilidad Percibida, Teoría de Confirmación de Expectativas, Turismo y Hotelería.

1. Introduction

Artificial intelligence (AI) technologies have the potential to transform smart tourism by facilitating personalised tour experiences at historical and/or cultural sites and improving the efficiency of planning and logistics (Arora & Chandel, 2024; Branstrator et al., 2023; Rita et al., 2025). AI-driven systems, leveraging cognitive and data-processing capabilities, analyse vast amounts of data to offer tailored recommendations, optimise travel itineraries, and enhance customer service through augmented reality (AR) and mobile app-based assistants (Anand et al., 2023; Khan et al., 2024). In addition, managing smart tourist flows through AI is significantly enhanced by AR mobile apps (Branstrator et al., 2023), which foster eco-friendly practices by offering real-time insights and predictive analytics of historical places. El Archi et al. (2023) and Arora and Chandel (2024) suggested that integrating AI with



AR enriches the tourists' experiences and supports sustainable tourism development. AR mobile apps incorporate historical places into virtual content, such as videos and pictures, in real time, which is essential for developing visitors' intention to use AR mobile apps (Fatma & Bhatt, 2023; Guerreiro et al., 2024).

However, considering the current popularity of AR technologies, several service industries are utilising AR to promote their offerings, and AR/VR technologies are projected to generate US\$40.4 billion in revenue in 2024 (Statista, 2024). In this view, several recent studies on the tourism industry have emphasised that AR technology has emerged as a transformative tool, revolutionising how tourists engage with destinations and attractions (Orru et al., 2018). By seamlessly blending virtual information with the real-time environment, AR mobile apps offer interactive and immersive experiences that enhance visitors' enjoyment, knowledge acquisition, satisfaction, and overall intention to use (Coghlan, 2021; Branstrator et al., 2022; Ariza-Colpas et al., 2023). AR mobile apps with such unique characteristics are also well-suited for smart tourism, where travellers seek authentic and immersive experiences that connect them with their culture, history, and heritage. Likewise, Akhtar et al. (2021) highlighted the potential of AR mobile apps to influence tourists' intention to use them by offering several vital features, including real-time virtual navigation of historical sites and ancient ruins, particularly in historically rich countries like Pakistan. Therefore, Table 1 presents some well-known real-world AR apps and highlights their main tourism functions, thereby providing practical examples of how such technologies assist tourists during destination experiences.

Table 1. Examples of AR-Based Mobile Applications Used in Tourism and Destination Experiences

Application	Tourism context	Real-time/immersive function	Relevance to this study
Google Maps Live View / Google AR Maps	Urban navigation and destination wayfinding	Uses AR overlays to guide users through walking directions in the real-world environment	Closely linked to the app context used in this study
PeakVisor	Mountain, hiking, and adventure tourism	Identifies mountains and supports tourists with AR, 3D maps, trails, and destination information	Relevant for nature and adventure tourism experiences
Smartify	Museums, galleries, heritage, and cultural tourism	Supports cultural visits through scanning objects, audio tours, guides, videos, and visit planning	Shows how mobile apps enrich cultural interpretation
Bloomberg Connects	Museums, galleries, gardens, and cultural spaces	Provides interactive digital guides, maps, audio, video, and curated cultural content	Demonstrates app-supported visitor engagement
StreetMuseum	Heritage and historical tourism	Uses GPS-linked AR/VR to recreate historical sites and provide audio-guided interpretation	Shows how AR can simulate past environments in real destination spaces

Pakistan, renowned for its rich cultural heritage, historical sites, and diverse landscapes, offers immense potential for the tourism industry through the integration of AR mobile apps (Bhartwal et al., 2024). Pakistan boasts a wealth of archaeological treasures, including ancient civilisations such as the "Indus Valley Civilisation and the "Gandhara Civilisation." However, Pakistan's stunning natural landscapes, from the snow-capped peaks of the "Himalayas" and "K2 Mountain" to the pristine beaches of the "Arabian Sea," offer ample opportunities for AR-enhanced tourism experiences (Tasneem et al., 2022). Whether trekking in the "Himalayan foothills," exploring the "Thar Desert" on camelback, or snorkelling in the crystal-clear waters of the "Arabian Sea," AR mobile apps have the capabilities to enhance outdoor adventures by providing real-time information, navigation assistance, and interaction (Shoib & Saleem, 2023; Saleem et al., 2022). From heritage tourism to adventure tourism, cultural tourism to ecotourism, AR mobile apps have the potential to add a new dimension to the visitor experience, making Pakistan a must-visit destination for travellers worldwide.

Despite growing interest and the significant potential of AR mobile apps in tourism, empirical research on their impact on tourists' behaviours and perceptions remains scarce, particularly in emerging economies such as Pakistan. Understanding how AR technology influences tourists' experiences, satisfaction, and intention to return is essential for tourism stakeholders, policymakers, and destination managers seeking to leverage this technology to enhance visitor engagement and sustainable tourism development. Also, prior tourism literature has largely treated AR technologies as a whole and has not differentiated among the devices used (Orús, Ibáñez-Sánchez, & Flavián, 2021).

Although AR has received growing attention in existing smart tourism research (Akhtar et al., 2021), important empirical gaps remain in explaining tourists' post-use evaluations and continuance usage intention, particularly in emerging tourism destinations. Therefore, a wide range of studies has examined AR adoption, perceived enjoyment, engagement, destination image, and general user experience (Saleem et al., 2022; Dağ et al., 2024). However, few studies have examined why tourists continue to use AR mobile applications after direct destination-based experiences. This distinction is important because initial adoption and continued usage do not indicate the same concept. A tourist may try an AR application out of curiosity or novelty. However, continued use depends on whether the application meets expectations, provides satisfaction, and offers useful support during the trip.



Furthermore, findings and future research directions from the recent studies in tourism are presented in Appendix 1. To further position the present study and underscore its relevance, the literature was reviewed to identify the research gaps using combinations of keywords and search terms commonly used in academic databases, including CAPES, Web of Science (WoS), and Scopus. The search terms included "AR mobile applications", "mobile augmented reality", "augmented reality", "tourist experience", "smart tourism", "tourism technology", "continuance intention", "continued use intention", "expectation-confirmation model", "perceived usefulness", "satisfaction", "telepresence", "interactivity", "Pakistan", and "emerging economies". These literature search combinations helped identify the growing body of empirical work on AR mobile apps in the tourism sector, while also demonstrating the limited existing empirical attention paid to tourists' continuance usage intention for AR mobile applications in Pakistan. This gap is important to address because Pakistan offers rich cultural, heritage, religious, and adventure tourism potential, yet wide research work on technology-enabled tourist experiences in this context remains underdeveloped.

This study aims to address the abovementioned research gaps by investigating the determinants of tourist experiences when using AR mobile apps. The study constructs include AR mobile app features based on telepresence and interactivity, perceived usefulness, confirmation of expectations, satisfaction, and continuance usage intention. The telepresence model (Steuer, 1992) and expectation-confirmation theory (Oliver, 1980) are adopted as relevant theories to guide this empirical investigation and provide the necessary foundation for the present study's hypotheses. The study contributes to understanding the underlying process that explains potential tourists' experiences with AR technologies in the tourism and hospitality industry. In addition, this study also contributes to the existing literature on AR mobile apps in tourism and hospitality by proposing and empirically validating a comprehensive framework that explains tourists' decisions to use AR mobile apps and their likelihood of becoming repeat users. From a managerial perspective, analysing the specific devices used in AR experiences (e.g., AR mobile apps) and their interplay with customers' behavioural intentions may enable the tourism and hospitality industry to create and deliver enhanced value propositions to potential customers. Lim et al. (2024) stated that understanding the importance of AR mobile apps and their role in driving repeat usage can help destination marketers and tourism service providers develop more user-friendly and appealing AR mobile apps, thereby creating more engaging experiences and fostering long-term relationships with tourists.

The paper is organised as follows. The paper begins with an introduction to AR technology in tourism, highlighting its significance and introducing the research gap. Following this, a concise literature review examines existing research on AR mobile apps in tourism, identifies gaps, and justifies the need for the current study. The theoretical framework section presents the conceptual model guiding the study (Figure 1). The methodology section outlines the research design, data collection methods, and analysis techniques. Results present findings from data analysis, focusing on significant relationships and mediation effects. The discussion section interprets the findings, discusses their implications, and suggests future research directions. Finally, the conclusion summarises key findings and recommendations.

2. Theoretical and Hypotheses Development

2.1 Telepresence Model

The telepresence model is rooted in media richness theory, which posits that richer media environments can better simulate real-life experiences (Steuer, 1992). Empirical studies have indicated that the telepresence model may enhance users' interactive experience with virtual objects (videos and pictures) in real-time environments (Angelino et al., 2021; Saleem et al., 2022). According to the telepresence model, users who experience virtual objects in a real environment are more likely to enter a state of flow characterised by deep immersion and enjoyment (Novak et al., 2000). In tourism, AR mobile apps create a strong sense of telepresence, enriching users' experiences and making them more valuable and memorable, especially at historical sites (Orru et al., 2018; Hoang et al., 2023). Similarly, Yoo et al. (2023) outlined a positive relationship between telepresence constructs and perceived usefulness toward safety culture in Korean training institutions. Madi et al. (2024) examined and concluded that there was a significant and positive correlation between AR mobile apps and tourists' perceived usefulness in Jordan. In this study, AR mobile app experience is conceptualised as a higher-order construct represented by two experiential dimensions (i) interactivity and (ii) telepresence. Interactivity refers to the extent to which tourists perceive that the AR mobile app enables them to engage with destination-related information, app-based guidance, virtual content, and the surrounding tourism environment (Steuer, 1992). Telepresence refers to the psychological sense of being present in an enhanced or simulated environment created through the AR interface (Wei & Li, 2021). AR mobile apps that address both key dimensions play an important role in improving perceived usefulness by providing tourists with real-time support, destination information, visual guidance, and interactive features during the travel experience. Therefore, few previous studies have integrated telepresence constructs (i.e., telepresence and interactivity) into AR mobile apps to investigate their impact on tourists' perceived usefulness in Pakistan. Thus, the study formulated the following hypothesis based on the arguments and criticisms in the above literature.

H1: AR mobile apps have a significant positive impact on perceived usefulness.



AR mobile apps play an important role in enhancing user satisfaction because tourism is an experiential activity in which tourists evaluate not only functional information but also enjoyment, immersion, novelty, and convenience. In this view, AR mobile apps allow tourists to interact with destination-related virtual content and feel more immersed in the tourism environment, which leads to more engaging and memorable experiences (Angelino et al., 2021; Dağ et al., 2024), and such experience-based values enhance tourists' satisfaction level with AR mobile apps during their trips. Numerous recent empirical studies have found that AR mobile apps have a significant and positive effect on user satisfaction. For example, Anand et al. (2022) highlighted that the real-time interaction of AR mobile apps enables users to stay engaged, leading to higher satisfaction for most users. The potential use of AR mobile apps enriches tourists' experiences of decade-old historical places, something that would have been impossible to know in a real-time environment. In this regard, the tourism industry is adopting advanced AR technologies to present cultural and historical sites, ultimately leading to higher satisfaction among tourists (Jiang et al., 2022). Therefore, studies such as Dağ et al. (2024) have pointed out that, due to the novelty of AR mobile apps, developing and historically rich countries are still striving to create advanced AR mobile apps to educate visitors about historic sites through virtual environment presentations. Kim & Hyun (2016) explored the concept of telepresence in AR mobile app support to simulate real-time experiences, thereby enhancing user satisfaction. Accordingly, Tom Dieck et al. (2023) confirmed a positive association between telepresence model-based AR mobile apps and users' satisfaction in virtual environments. Thus, the following hypothesis was formulated based on the literature review above.

H2: AR mobile apps have a significant positive impact on satisfaction.

In the expectation-confirmation model, confirmation occurs when users compare their initial expectations with their experience (Lee, J., & Kim, 2020). In the context of AR mobile apps, tourists form expectations about navigation, access to information, visual support, and ease of use before or during the trip. When the AR application provides real-time guidance, destination information, and interactive visual support, tourists can evaluate whether the experience meets or exceeds their expectations (Orús et al., 2021). A recent empirical study by Calderón-Fajardo et al. (2022) found that AR mobile apps offer immersive and interactive travel experiences that significantly and positively influence users' intentions to use them. Similarly, Alamäki et al. (2021) investigated and concluded that AR mobile apps significantly influence the confirmation of expectations, ultimately shaping positive user perceptions. Confirming user expectations is crucial to engaging travellers with AR mobile apps when visiting historical heritage sites (Alqahtani et al., 2018). In addition, Kim et al. (2016) revealed that the interactivity of AR mobile apps in tourism fosters user engagement, enhancing perceived experience towards the virtual environment and shaping positive expectation confirmation.

Furthermore, the study emphasised the ability to integrate virtual tourist sites into physical environments to enhance users' intention to use AR mobile apps to learn more about these places. In this view, Alqahtani et al. (2018) examined the role of information quality in historical places using AR mobile apps, anticipating high user expectations, and found a positive impact on users' expectation confirmation. Therefore, existing empirical studies on the use of AR mobile apps in the tourism and hospitality industry and their impact on the confirmation of expectations in Pakistan are limited. Thus, the present study addresses the abovementioned gap by proposing the following hypothesis.

H3: AR mobile apps have a significant positive impact on the confirmation of expectations.

2.2 Expectation-Confirmation Model

The Expectation Confirmation Model (ECM), coined by Oliver (1980), aims to explain users' satisfaction with a newly adopted information system and/or service. According to Mamun et al. (2020), the ECM was formulated to predict users' real-time expectations and experiences concerning services or products. Comprehensive research has investigated users' perceived usefulness, satisfaction, and expectation confirmation based on the congruence between their real-time experiences and intended product or service usage intention using ECM. Notably, perceived usefulness is a dominant variable of EXM. Perceived usefulness supports the prediction of satisfaction because users are generally more satisfied when a technology helps them perform a task more effectively (Yoo et al., 2023). In tourism, an AR mobile app may be perceived as useful when it helps tourists. In tourism, perceived usefulness can be conceptualised as tourists' assessment of how AR mobile apps can enhance their overall travel experience, primarily by helping them locate places, understand destination features, access relevant information, and improve the quality of their trip (Kim et al., 2017). The benefits of AR mobile apps may include streamlined booking processes, readily accessible information, and enhanced educational opportunities about the environment and local cultures (Leou & Wang, 2023). Similarly, a study by Madi et al. (2024) found that the perceived usefulness of AR mobile apps significantly affected user satisfaction. The study outlined tourists' appreciation for features such as real-time information, environmental education, and user-friendly interfaces, collectively contributing to their overall satisfaction.

On the other hand, Do et al. (2020) investigated and concluded that AR mobile apps significantly impact consumers' intention to use in Vietnam. Likewise, Calderón-Fajardo et al. (2022) found similar results in Spain. Previously, few empirical studies have examined the impact of perceived usefulness on satisfaction and continuance usage intention for AR mobile apps in the Pakistani context. The following hypotheses are proposed to address this gap.



H4: Perceived usefulness has a significant positive impact on satisfaction.

H5: Perceived usefulness has a significant positive impact on continuance usage intention.

Confirmation of expectations reflects the alignment between a user's pre-experience beliefs and post-experience (Oliver, 1980). Empirically, the relationship between the confirmation of expectations and satisfaction is well established across the service-sector literature, including tourism. According to Thong et al. (2006), confirmation of expectations is expected to influence satisfaction, as satisfaction depends on the extent to which experience matches or exceeds prior expectations. When tourists find that the AR mobile app performs better than expected or meets their expectations for service quality, confirmation may stem from accurate navigation, useful destination information, clear visual support, and a positive app-use experience. The consistency between users' beliefs and a service's real-time experiences is grounded in ECT (Brown et al., 2014). In tourism and hospitality, expectations are directly linked to the quality and characteristics of visitor places through AR mobile apps, thereby leading to satisfaction and a positive post-tour behavioural intention (Lim et al., 2024). Notably, prior studies have found that expectation confirmation has a significant positive effect on satisfaction with AR mobile apps. For example, a recent empirical survey of nature-based tourism indicates that tourist satisfaction is significantly dependent on the confirmation of expectations (Oh et al., 2022). Accordingly, another study by Rasoolimanesh et al. (2023) demonstrated a direct, positive impact of expectations on tourist satisfaction. In addition, another recent study by Hoang et al. (2023) highlighted that tourists' experiences and expectations are agents in building intense satisfaction among tourists.

Furthermore, the study found that tourists' expectations are satisfied, leading to a greater inclination to revisit ecotourism destinations. Few studies have examined the impact of expectation confirmation on the satisfaction of tourists using AR mobile apps in Pakistan. Therefore, the following hypothesis is formulated to address the abovementioned research gap.

H6: Confirmation of expectations has a significant positive impact on satisfaction.

Satisfaction is a key driver of consumer behaviour, reflecting the degree to which a service meets customer expectations (Mamun et al., 2020). In tourism, user satisfaction is influenced by various factors, including service quality, unique natural and cultural experiences, and trip gratification (Saut & Ly, 2023; Ramos et al., 2024; Ozkan et al., 2024). ECT posits that satisfied customers are more likely to develop a positive disposition towards advanced services and exhibit a greater propensity to return (Oliver, 1980). In this view, Lee & Kim (2020) confirmed that higher user satisfaction strongly predicts repeat visits and future intention. Numerous existing tourism studies have demonstrated that satisfaction positively impacts the intention to continue using a service. For example, an empirical study by Kim et al. (2017) found that tourist experience and satisfaction significantly predict their intention to revisit and recommend the destinations to others. Similarly, a recent study by Adnan & Omar (2021) found that satisfied tourists were more likely to revisit the destination and engage in further ecotourism activities. Considering the importance of tourist satisfaction, the quality of offered services is an agent that enhances their experience and expectations, promotes continuance usage intention, and fosters sustainable tourism development (Rahman et al., 2018; Kamel, 2024). Despite the growing popularity of AR mobile apps in the tourism and hospitality industry, empirical studies on the impact of satisfaction on continuance usage intention in Pakistan are limited. Therefore, the following hypothesis is proposed to address the abovementioned research gap.

H7: Satisfaction has a significant positive impact on continuance usage intention

2.3 Mediation role of perceived usefulness, satisfaction, and confirmation of expectations

The present study is grounded in the expectation-confirmation model and the telepresence model. Prior studies argued that the AR mobile app experience may not influence continuance usage intention only through a direct route (Kim et al., 2016; Saleem et al., 2022). Instead, tourists' continued use is likely to depend on intermediate post-use evaluations, including whether the app confirms expectations, is perceived as useful, and whether it is satisfying. These mediating constructs help explain how the AR mobile app-enabled experience translates into future behavioural intention (Madi et al., 2024). Confirmation of expectations is proposed as a mediator because tourists evaluate AR mobile apps by comparing their experience with their prior expectations. If the AR app provides real-time guidance, interactive support, and useful destination information, tourists are more likely to have their expectations met, thereby increasing satisfaction.

First, in the present study, confirmation of expectations is proposed as a mediator, as tourists evaluate AR mobile apps by comparing their experiences with their prior expectations. In this view, Alqahtani et al. (2018) demonstrated that the AR app provides real-time guidance, useful destination information, and interactive support; tourists are more likely to confirm their expectations, thereby strengthening satisfaction and continuance usage intention. The AR mobile app experience may first confirm tourists' expectations (Jiang et al., 2022), and this confirmation may then increase satisfaction, ultimately supporting continuance usage intention (Kim et al., 2017). This sequence reflects the logic of the expectation-confirmation model, in which confirmation shapes satisfaction, and satisfaction drives continued use intention. Therefore, the present study proposed the following mediating hypotheses.



H8: Confirmation of expectations mediates the relationship between AR mobile apps and satisfaction.

H9: Confirmation of expectations and satisfaction sequentially mediate the relationship between AR mobile apps and continuance usage intention.

Second, in the present study, perceived usefulness is also expected to mediate the relationship between AR mobile apps and continuance usage intention. When tourists experience AR mobile apps as interactive and immersive, they may perceive them as more useful for travel-related tasks (Madi et al., 2024). This solid perceived usefulness may then encourage users to use it in the future. Thus, perceived usefulness mediates the relationship between AR mobile apps and satisfaction, as useful technologies are more likely to elicit positive evaluations. Anand et al. (2022) stated that if AR mobile apps improve tourists' travel experience, they may enhance satisfaction through perceived functional value. In addition, following the expectation-confirmation model, perceived usefulness and satisfaction operate sequentially. In sum, a positive AR mobile app experience enhances perceived usefulness, perceived usefulness builds solid satisfaction, and solid satisfaction then increases continuance usage intention. Therefore, the present study proposed the following hypotheses.

H10: Perceived usefulness mediates the relationship between AR mobile apps and continuance usage intention.

H11: Perceived usefulness mediates the relationship between AR mobile apps and satisfaction.

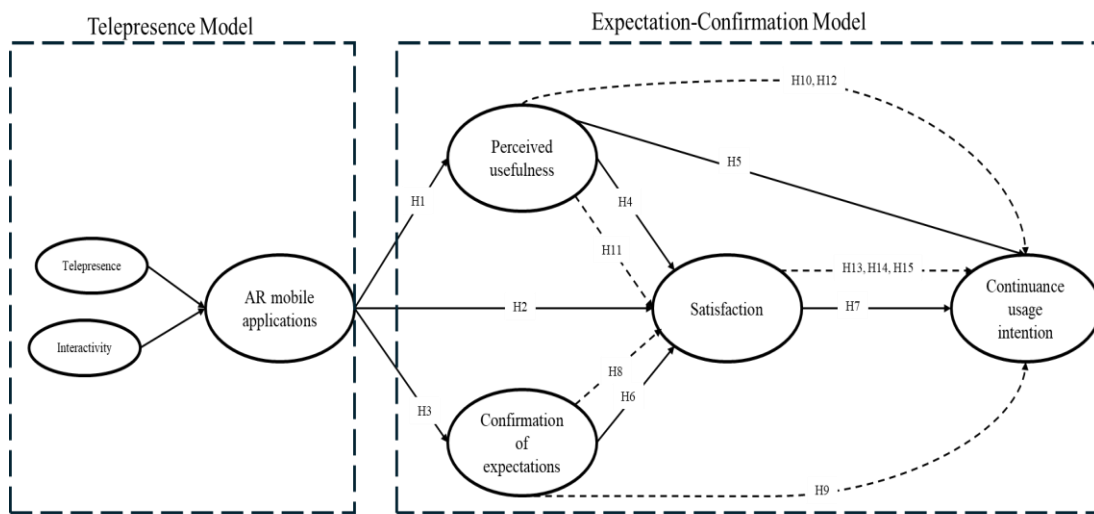
H12: Perceived usefulness and satisfaction sequentially mediate the relationship between AR mobile apps and continuance usage intention.

In the present study, satisfaction is proposed as a mediating variable between AR mobile apps and continuance usage intention, as Calderón-Fajardo et al. (2022) suggested that the AR-enabled mobile app experiences lead to continued use when they elicit positive affective evaluations. Thus, the tourists who are satisfied with the AR mobile app experience are more likely to use such applications again. Notably, satisfaction also mediates the relationship between confirmation of expectations and continuance usage intention. When tourists' expectations are confirmed, they are more likely to feel satisfied, and this satisfaction may encourage continued use (Kim et al., 2017). Finally, satisfaction mediates the relationship between perceived usefulness and continuance usage intention. While Anand et al. (2022) elaborated that if tourists perceive the AR app as useful, this leads to satisfaction, which subsequently strengthens their intention to continue using AR mobile applications. Previously, few tourism studies investigated its single- and sequential-mediating roles. Therefore, the present study aims to bridge the empirical gap by proposing the following hypotheses.

H13: Satisfaction mediates the relationship between AR mobile apps and continuance usage intention.

H14: Satisfaction mediates the relationship between confirmation of expectations and continuance usage intention.

H15: Satisfaction mediates the relationship between perceived usefulness and continuance usage intention.

**Figure 1. Conceptual Framework**

Source: own elaboration.

3. Methods

This study adopted a targeted approach to investigate the continuance intention to use AR mobile apps among tourists in Pakistan. Thirty tour companies based in Lahore, Karachi, and Islamabad, known for regularly organising tours to destinations across Pakistan, were approached for collaboration.

This study used a non-probability purposive sampling method because respondents were required to meet specific inclusion criteria. Eligible respondents had to be tourists who had recently participated in tourism activities in Pakistan and had used Google AR Maps during their trip. Therefore, the data were collected from November 2024 to February 2025 from tourists who had recently participated in tourism activities in Pakistan and used Google AR maps during their trip. Specifically, they were introduced to Google AR maps, which were installed on their smartphones. During the trip, tour guides assisted participants in using the AR app to enhance their travel experience. The present study focuses on Google AR Maps because it offers a real-world, AR-supported mobile experience that includes location-based guidance, visual orientation, and destination navigation. However, the study does not assume that Google AR Maps represents all possible AR tourism applications. This hands-on approach ensured that participants had practical exposure to AR technology in a real-world tourism context. After completing their trips, participants were invited to complete an online survey. The first question in the survey explicitly asked whether they had used Google AR maps during their trip.

Those who responded "No" were excluded from the study to ensure that only participants with direct AR experience were included. The final sample consisted of 343 individuals who met the criteria and provided complete responses. This methodology not only ensured that participants had a clear understanding of AR technology but also enabled a controlled, practical assessment of AR app usage in tourism. By focusing on a specific AR application (Google AR Maps) and providing hands-on guidance, the study addressed key concerns regarding participants' understanding and actual use of AR, thereby enhancing the validity and reliability of the findings.

The questionnaire was administered in "Urdu," the first language of Pakistan. The language was selected to ensure that respondents could clearly understand the survey items and provide accurate responses. Therefore, the final questionnaire was meticulously crafted and divided into sections (A and B). Section "A" covered the participants' demographic characteristics, while the second section, "B," contained items assessing five constructs using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." Drawing on validated scales from seminal works and existing studies, some modifications were made to the items to align with the present research objectives. The AR mobile app construct was operationalised as a second-order construct comprising interactivity and telepresence. This operationalisation follows the theoretical view that tourists evaluate AR mobile app experiences through both interactive and immersive qualities. Two dimensions of AR mobile apps: (i) telepresence, consisting of five items, were adapted from Novak et al. (2000), and (ii) interactivity, which was assessed using four items adapted from Liu et al. (2010). Perceived usefulness, comprising three items, was adapted from the seminal works of Davis (1989) and Bhattacharjee et al. (2008), while confirmation of expectations includes three items adapted from Bhattacharjee (2001). Satisfaction was assessed with four items adapted from Thong et al. (2006) and Premkumar and Bhattacharjee (2008), while continuance usage intention was measured using four items adapted from Bhattacharjee (2001) and Liao et al. (2007).



To assess the reliability and validity of the measurement items, we conducted a pretest with four academic experts. The experts were selected following their research experience in smart tourism technologies, tourism management, and marketing from "University Technology Malaysia and Sindh University Jamshoro. They were invited for their extensive expertise in technology adoption research, survey design, and tourism-related consumer behaviour. The experts assessed the questionnaire for item clarity, wording, construct relevance, contextual suitability, and logical flow. Their detailed feedback mainly suggested simplifying some item wording, improving questionnaire formatting, and ensuring that the items were understandable to tourists with different levels of familiarity with AR mobile applications. Based on their feedback, minor revisions were made before conducting the pilot study and distributing the final survey. Therefore, a pilot study was conducted with 34 participants (tourists), all with prior experience using AR mobile apps, to learn about places to establish and confirm face validity. Overall, these steps for establishing content and face validity align with the guidelines outlined by Lim et al. (2024). Participants primarily suggested improving the questionnaire's clarity and format; thus, we incorporated these suggestions before distributing it to the primary study sample.

First, the data were analysed using "Partial Least Squares Structural Equation Modelling" (PLS-SEM). PLS-SEM was chosen for its suitability in analysing complex relationships among latent constructs, particularly in studies with small sample sizes and non-normal data distributions (Hair et al., 2014). Second, descriptive statistics were utilised to calculate respondents' demographic characteristics. Second, the measurement model was assessed using factor loadings, Cronbach's alpha, composite reliability, and average variance extracted to validate indicator reliability, internal consistency, and convergent validity. Third, discriminant validity (Fornell-Larcker Criterion) was assessed. Fourth, the structural model was evaluated using path coefficients, t-statistics, p-values, and R^2 values to test the proposed direct hypotheses and assess the model's explanatory power. Finally, direct, indirect, and sequential mediation effects among AR mobile apps, perceived usefulness, confirmation of expectations, satisfaction, and continuance usage intention were assessed by using the bootstrapping approach.

3.1 Common Method Bias

Since the study used self-reported survey data, common method bias was assessed using full collinearity VIFs. All constructs met the recommended threshold of 3.3, with VIF values below the cut-off point. As shown in Table 2, the VIF values ranged from 1.334 to 1.724, indicating that common method bias was not a serious concern in this study.

Table 2. Full collinearity VIFs for common method bias

Construct	Full collinearity VIF
Confirmation of expectations	1.334
Continuance usage intention	1.422
Interactivity	1.392
Perceived usefulness	1.464
Satisfaction	1.724
Telepresence	1.356

4. Results

4.1 Demographic Characteristics

The demographic profile of the participants, outlined in Table 3, provides a comprehensive overview of key characteristics within the sample of 343 individuals. The demographic data reveal a male-to-female ratio of 58% to 42%, with 60% aged 26-35 and 61% holding a bachelor's degree, highlighting a young, educated group. Income is diverse, with 24.5% earning between PKR 50,000 and PKR 69,999. Leisure travel (13.1%) and frequent travel patterns (22.4%) indicate a segment engaged with tourism, ideal for AR app experiences.

Table 3. Demographic Characteristics of Study Participants (n=343)

Characteristics	Frequency	Percent
Gender		
Male	199	58%
Female	144	42%
Age		
18-25	83	24%
26-35	206	60%
36-45	36	10%
Above 45	18	5%
Education		
Higher Secondary School	18	5%
Bachelor's degree	210	61%



Master's degree	111	32%
Doctoral Degree	4	1%
Annual Income (PKR)		
Less than 50,000	79	23
50,000–69,999	84	24.5
70,000–89,999	33	9.6
90,000–109,999	36	10.5
110,000–129,999	36	10.5
130,000 or more	75	21.9
Primary Purpose of Travel		
Leisure	45	13
Business	57	16.6
Cultural exploration	60	17.5
Adventure	77	22.4
Visiting friends/family	62	18
Other (please specify)	42	12
Frequency of Travel		
Less than once a year	74	21.6
Once a year	74	21.6
2–3 times a year	58	17
4–6 times a year	43	12.5
More than 6 times a year	94	27.5

4.2 Measurement model

The measurement model presented in Table 4 assesses five constructs used in this study, specifically AR mobile apps, perceived usefulness, confirmation of expectations, satisfaction, and continuance usage intention, through key analysis metrics (i.e., Cronbach's alpha (α), composite reliability, and average variance extracted (AVE)). Item loading for each construct is above the 0.7 threshold. Cronbach's alpha values for these constructs range from 0.713 to 0.842, indicating acceptable internal consistency, with all values surpassing the common threshold of 0.70. Composite reliability values, spanning from 0.757 to 0.894, further reinforce the reliability of these constructs, again all exceeding the acceptable threshold of 0.70. The AVE values, which range from 0.513 to 0.681, indicate that each construct explains a significant portion of the variance, with all values above the 0.50 threshold.

Therefore, Table 5 presents the discriminant validity of the constructs using the Fornell-Larcker criterion, which ensures that each construct is distinct from the others in the model. The diagonal values in the table represent the square root of the average variance extracted (AVE) for each construct, while the off-diagonal values represent the correlations between the constructs. For each construct, the square root of the AVE should be higher than its correlations with other constructs. For AR mobile apps, the square root of AVE is 0.81, indicating good discriminant validity as it is higher than its correlations with other constructs. Similarly, confirmation of expectations has a square root of AVE of 0.779, which is also greater than its correlations with other constructs, supporting its discriminant validity. Continuance usage intention shows a square root of AVE of 0.825, higher than its correlations, confirming good discriminant validity. Perceived usefulness, with a square root of AVE of 0.716, and satisfaction, with a square root of AVE of 0.727, exhibit values higher than their respective correlations with other constructs, indicating acceptable discriminant validity.

Table 4. Measurement model

Items and constructs	Loadings	α	CR	AVE
<i>Augmented Reality Applications</i>		0.776	0.792	0.656
Interactivity		0.708	0.733	0.597
ITY1: "I could have a trip discussion with others using the AR app."	0.797			
ITY 2: "I could communicate with others on the AR app."	0.803			
ITY 3: "I could send instant messages on the AR app."	0.777			
ITY 4: "I think the virtual environment of the AR app provides a good chance to interact with historical places."	0.724			
Telepresence		0.731	0.747	0.589
TEL1: "When using the AR app, I forget about the real environment."	0.74			
TEL2: "After using the AR app, I feel I just had a journey."	0.704			
TEL3: "When using the AR app, it seems that I was put in another world the app created."	0.709			
TEL4: "When I stopped using the AR app, the virtual environment suddenly disappears."	0.775			
TEL5: "When using the AR app, my body is in the room, but my mind is in the virtual world."	0.713			
<i>Perceived Usefulness</i>		0.713	0.757	0.513



Items and constructs	Loadings	α	CR	AVE
PU1: "Using the AR app on my trip increases my productivity."	0.803			
PU2: "Using the AR app in my trip makes me more effective."	0.738			
PU3: "I find the AR app to be useful in my trip."	0.713			
<i>Confirmation of Expectations</i>		0.768	0.823	0.607
COE1: "My experience using the AR app is better than I expected."	0.764			
COE2: "The AR app service level is better than I expected."	0.776			
COE3: "Overall, most of my expectations from using the AR app are confirmed."	0.797			
<i>Satisfaction</i>		0.795	0.815	0.528
SAT1: "My experience with AR app use was very satisfactory."	0.703			
SAT2: "My experience with AR app use was very pleasant."	0.800			
SAT3: "My experience with AR app use was delightful."	0.819			
SAT4: "My experience of AR app use was very contented."	0.762			
<i>Continuance Usage Intention</i>		0.842	0.894	0.681
CINT1: "I intend to continue using the AR app on my travel."	0.825			
CINT2: "I will use the AR app regularly in the future."	0.886			
CINT3: "I intend to continue using the AR app rather than use any alternative means."	0.868			
CINT4: "If I could, I would like to continue using the AR app as much as possible."	0.71			

Table 5. Discriminant validity (Fornell-Larcker Criterion)

	(1)	(2)	(3)	(4)	(5)
(1) AR app	0.810				
(2) COE	0.409	0.779			
(3) CINT	0.340	0.201	0.825		
(4) PU	0.503	0.396	0.293	0.716	
(5) SAT	0.483	0.355	0.528	0.359	0.727

4.3 Direct hypothesis testing

Table 6 presents the direct effects among the study's constructs, measured using path coefficients, standard deviations, T-statistics, and P-values, along with the results of hypothesis testing. The results indicate that the AR mobile apps significantly impact perceived usefulness ($\beta = 0.503$), satisfaction ($\beta = 0.360$), and confirmation of expectations ($\beta = 0.409$); thus, H1-H3 are accepted. Surprisingly, perceived usefulness has an insignificant impact on satisfaction ($\beta = 103$); therefore, H4 is rejected. On the other hand, perceived usefulness significantly impacts continuance usage intention ($\beta = 0.118$); therefore, H5 is accepted. Confirming expectations also significantly impacts satisfaction ($\beta = 0.164$), supporting H6. Lastly, satisfaction significantly impacts continuance usage intention, as indicated by the statistical value ($\beta = 0.486$); thus, H7 is accepted. In addition to the path coefficients, f^2 effect sizes were reported to assess the substantive contribution of each exogenous construct to the corresponding endogenous construct. The results indicate that AR mobile apps, perceived usefulness, confirmation of expectation, and satisfaction made meaningful contributions to the model.

Table 6. Direct Hypotheses and Effect Size

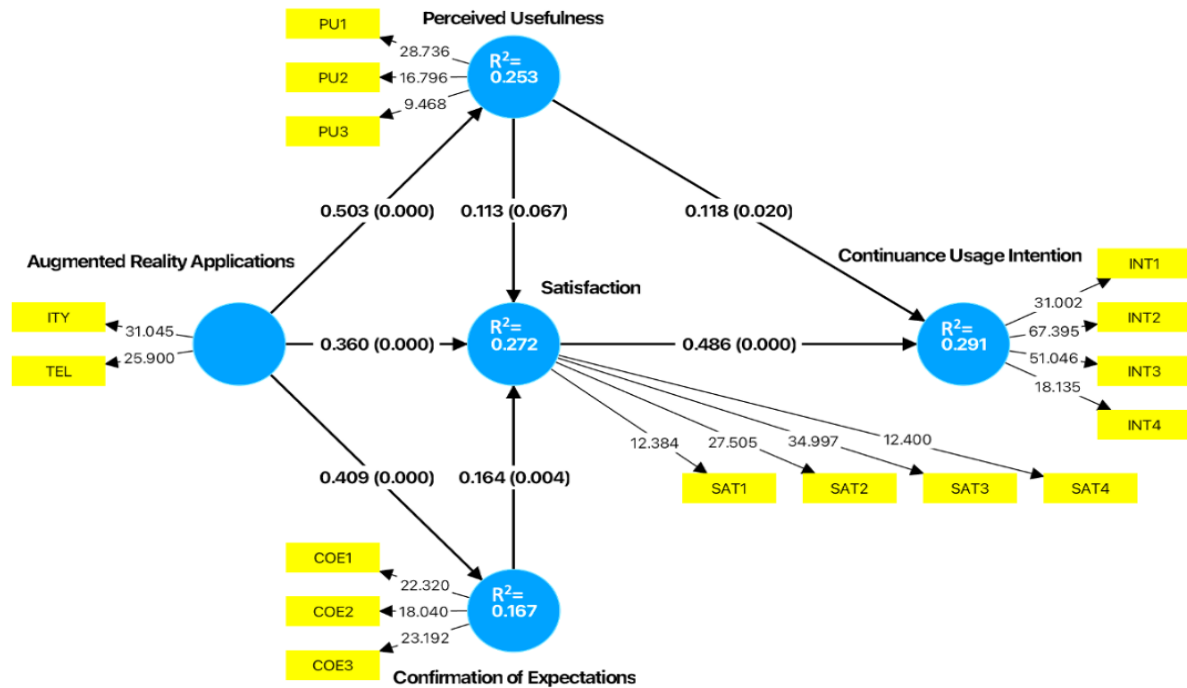
	Paths	f^2	β	T statistics	P values	Results
H1	AR apps $\rightarrow$ PU	0.211	0.503	11.609	0.000	Accepted
H2	AR apps $\rightarrow$ SAT	0.348	0.360	6.456	0.000	Accepted
H3	AR apps $\rightarrow$ COE	0.112	0.409	8.972	0.000	Accepted
H4	PU $\rightarrow$ SAT	0.108	0.103	1.83	0.067	Rejected
H5	PU $\rightarrow$ CINT	0.101	0.118	2.325	0.020	Accepted
H6	COE $\rightarrow$ SAT	0.130	0.164	2.879	0.004	Accepted
H7	SAT $\rightarrow$ CINT	0.291	0.486	10.275	0.000	Accepted

Furthermore, the model's independent variables, including AR mobile apps, explain a moderate to substantial portion of the variance (R^2) in the dependent variables, as shown in Figure 2. Perceived usefulness (25.3%), satisfaction (27.2%), and intention to



continue using the technology (29.1%) exhibit stronger relationships with the independent variables than confirmation of expectations (16.7%). The tourists' perceptions are shaped by several psychological, technological, contextual, and destination-related factors; therefore, the AR mobile app experience provides a meaningful but partial explanation of perceived usefulness and confirmation of expectations. In addition, the Q^2 predict values were positive for perceived usefulness (0.244), satisfaction (0.227), confirmation of expectations (0.158), and continuance usage intention (0.110), confirming the model's predictive relevance

Figure 2. Structural Model



Source: own elaboration.

4.4 Mediating hypotheses testing

Table 7 presents the mediating roles of confirmation of expectations, perceived usefulness, and satisfaction in the relationship between AR mobile apps and continuance usage intention. The mediating hypotheses reveal that AR mobile apps indirectly affect satisfaction ($\beta = 0.067$), supporting H8. The second sequential hypothesis demonstrated that the confirmation of expectations and satisfaction sequentially mediate the relationship between AR mobile apps and continuance usage intention ($\beta = 0.032$), supporting H9. Additionally, perceived usefulness mediates the relationship between AR mobile apps and continuance usage intention ($\beta = 0.059$). However, H10 is accepted; surprisingly, it does not mediate the relationship between AR mobile apps and satisfaction ($\beta = 0.057$); thus, H11 is rejected. Accordingly, the sequential mediating role of perceived usefulness and satisfaction does not mediate the relationship between AR mobile apps and continuance usage intention ($\beta = 0.028$); thus, H12 is rejected. Furthermore, satisfaction mediates the relationship between AR mobile apps and continuance usage intention ($\beta = 0.175$) and confirmation of expectation and continuance usage intention ($\beta = 0.079$); thus, H13 and H14 are accepted. In the final mediating hypothesis, satisfaction does not mediate the relationship between perceived usefulness and continuance intention to use ($\beta = 0.055$); therefore, H15 is rejected.

Table 7. Mediating and Sequential Mediating Hypotheses

	<i>Paths</i>	<i>β</i>	<i>T statistics</i>	<i>P values</i>	<i>Results</i>
H8	AR apps $\rightarrow$ COE $\rightarrow$ SAT	0.067	2.806	0.005	Accepted
H9	AR apps $\rightarrow$ COE $\rightarrow$ SAT $\rightarrow$ INT	0.032	2.684	0.007	Accepted
H10	AR apps $\rightarrow$ PU $\rightarrow$ INT	0.059	2.308	0.021	Accepted
H11	AR apps $\rightarrow$ PU $\rightarrow$ SAT	0.057	1.829	0.067	Rejected
H12	AR apps $\rightarrow$ PU $\rightarrow$ SAT $\rightarrow$ CINT	0.028	1.771	0.077	Rejected
H13	AR apps $\rightarrow$ SAT $\rightarrow$ CINT	0.175	5.077	0.000	Accepted
H14	COE $\rightarrow$ SAT $\rightarrow$ CINT	0.079	2.762	0.006	Accepted
H15	PU $\rightarrow$ SAT $\rightarrow$ CINT	0.055	1.779	0.075	Rejected



5. Discussion

This study investigates the relationship between AR mobile apps, perceived usefulness, satisfaction, and expectation confirmation on tourists' continuance usage intention in Pakistan. Results demonstrate a significant positive influence of AR mobile apps on multiple dimensions of tourist experiences. Findings from this study align with and extend existing literature on the adoption of AR mobile apps in the tourism and hospitality industry.

First, the significant positive impact of AR mobile apps on perceived usefulness (H1) aligns with previous research demonstrating that technological innovation can enhance the tourist experience by providing valuable, interactive, and easily accessible information about historical sites. For instance, an empirical study by Madi et al. (2024) has demonstrated that AR mobile apps significantly enhance the effectiveness and efficiency of information retrieval, thereby boosting overall utility for tourists. The findings from this study indicate that AR mobile apps offer practical benefits and integrate seamlessly into tourists' decision-making processes, further validating the ECM in a tourism context.

Second, in exploring the relationship between AR mobile apps and satisfaction (H2), the findings suggest that AR mobile apps significantly and positively enhance tourists' satisfaction with their tourism experiences. Prior studies, such as Tom Dieck et al. (2023), reported higher satisfaction levels among tourists who used AR mobile apps. The interactive features of AR mobile apps appear to be crucial for optimising and validating user engagement, ultimately resulting in highly satisfying experiences when exploring historical sites (Liu et al., 2010). Our findings highlight the importance of users' satisfaction levels in fostering repeat visitation when using AR mobile apps, a fundamental factor in the sustainability of tourist destinations.

Third, confirming tourists' expectations through AR mobile apps (H3) is another substantial statistical finding reinforcing ECT. The present study's findings align with the previous studies on tourism. For instance, Alamäki et al. (2021) investigated and concluded that AR mobile apps help bridge the gap between expectations and experiences by offering real-time confirmation of expectations, thereby narrowing the gap between pre-trip expectations and experiences. Accordingly, Kim et al. (2016) stated that by providing real-time information, AR mobile apps influence tourists' anticipations to be met or exceeded, fostering a positive perception of the destination.

Fourth, perceived usefulness positively influences satisfaction (H4), which was not supported. While perceived usefulness is essential, our findings indicate an unfavourable relationship between this construct and tourist satisfaction when using AR mobile apps. It has been found that perceived usefulness is a strong predictor of user satisfaction across various technology adoption contexts (Davis, 1989). On the other hand, in the adoption context of AR mobile apps in tourism, other factors, such as the novelty of the technology and the immersive experience, might play a negative role in determining satisfaction levels (Leou & Wang, 2023). Amalia & Fahrudi (2021) also found a negative relationship between perceived usefulness and satisfaction while using a new technology.

Fifth, (H5) suggests that the perceived usefulness positively influences continuance usage intention. This finding aligns with the ECT, indicating that users who perceive AR mobile apps as valuable are more likely to continue using them. Empirical support for this relationship is evident in a study by Rasoolimanesh et al. (2023), who demonstrated that perceived usefulness is a critical factor influencing users' intentions to continue using a technology adoption. In the tourism context, Hoang et al. (2023) found that the perceived usefulness of mobile apps significantly influenced tourists' propensity to use mobile apps repeatedly. This reinforces the importance of designing AR mobile apps that deliver clear, practical user benefits, particularly for historical sites.

Sixth, (H6) posits a positive relationship between confirmation of expectations and satisfaction. Statistical analysis confirms this hypothesis, indicating that overall satisfaction is enhanced when tourists' expectations are met or exceeded through their AR mobile app experiences. This finding aligns with the ECT, which posits that satisfaction is a function of the confirmation of pre-usage expectations. Research by Lee & Kim (2020) empirically supported our findings, showing that users are more satisfied when their initial expectations are met or surpassed. In the tourism industry, Rahman et al. (2018) found that the confirmation of expectations through technological interventions such as AR mobile apps significantly enhances tourist satisfaction.

Finally, the present study tested the mediating roles of confirmation of expectations, satisfaction, and perceived usefulness in the relationship between AR mobile apps and tourists' continuance usage intention in Pakistan. Where (H8-H10 and H13-H14) were supported, this suggests the importance of meeting tourists' expectations, enhancing satisfaction levels, and delivering perceived value to encourage repeat visits. The significant mediating effect of confirmation of expectations between AR mobile apps and satisfaction indicates that AR-enabled experiences improve satisfaction by helping tourists confirm their expectations. This reveals that tourists are more satisfied when the app experience meets or exceeds their expectations before or during the trip. In addition, the significant sequential mediation via confirmation of expectations and satisfaction further indicates that AR mobile apps drive continuance usage intention through post-use evaluation. In other words, the AR mobile app experience first shapes tourists'



confirmation judgments; confirmation then enhances satisfaction; and satisfaction subsequently enhances continuance usage intention. These empirical findings support the expectation-confirmation logic and highlight that continued use of AR mobile apps depends not only on exposure to AR features but also on whether tourists evaluate the experience positively after use.

However, the non-significant mediation effects found in (H11, H12, and H15) suggest that perceived usefulness alone may not fully mediate the relationship between AR mobile apps and tourists' satisfaction and continuance usage intention. The mediation role of perceived usefulness also suggests that AR mobile apps promote continuance usage intention when tourists perceive them as useful for travel-related activities. However, the insignificant mediation effects involving perceived usefulness and satisfaction indicate that preserved usefulness alone may not be sufficient to generate satisfaction in AR-supported tourism practices. Tourists may find an AR app useful, but their satisfaction may depend more on immersion, visual quality, destination relevance, novelty, enjoyment, and emotional engagement. Thus, AR tourism mobile apps should not only provide functional guidance but also create engaging and meaningful destination experiences.

5.1 Theoretical implications

The present study theoretically contributes to the existing body of literature. It extends our understanding of how to integrate AR mobile apps in the tourism and hospitality industry by empirically testing the telepresence model and the ECM dimensions. By investigating the associations between the key constructs, such as AR mobile apps, perceived usefulness, satisfaction, confirmation of expectations, and continuance usage intention, this study advances our understanding of the utilisation of AR mobile apps to enhance tourist experiences, particularly in emerging markets like Pakistan.

First, the study confirms the relevance of the telepresence model in explaining how AR mobile apps enhance the tourist visual experience by creating immersive, interactive virtual environments that shape consumer behaviour. We expand the scope of the telepresence model as a conceptual framework by integrating one of the most extensive applied theories in AR mobile apps. Thus, the findings from the present study confirm that the perceived usefulness, satisfaction, confirmation of expectations, and continuance usage intentions vary in their capacity to evoke the telepresence model, as suggested by Bhattacharjee (2001). Additionally, the present research contributes new knowledge to tourism and hospitality by offering a more comprehensive theoretical perspective of the telepresence model. In addition, telepresence notably influences perceived usefulness and satisfaction, which refers to the sense of "being there" in a virtual environment. These findings are supported by prior studies that indicate telepresence in AR environments boosts user satisfaction and engagement (Novak et al., 2000; Saleem et al., 2023). The immersive capabilities of AR mobile apps are especially valuable for expanding knowledge of their influence in the tourism and hospitality industry.

Second, the study extends the ECM by demonstrating that the confirmation of expectations positively influences satisfaction, which in turn shapes overall continuance usage intention. This finding advocates the significance of managing tourists' expectations to sustain long-term engagement with AR technology. Existing studies, such as Rasoolimanesh et al. (2023), have emphasised the importance of expectation confirmation in driving satisfaction and continued intention to use advanced technologies. However, a noteworthy theoretical contribution is the finding that perceived usefulness did not significantly predict satisfaction, contrary to expectations based on prior research (Oliver, 1980). This suggests that while tourists may find AR helpful, their overall satisfaction may depend more on other factors, such as novelty or the hedonic aspects of their experiences.

5.2 Managerial and practical contributions

The present study's findings hold significant implications for practitioners and policymakers, including the Ministry of Tourism, travel and tour agencies, digital marketing agencies, and mobile application developers.

First, AR mobile apps should be designed and monitored to provide accurate, location-specific information about historical places and real-time updates. Tourists are more likely to perceive AR apps as useful when they help with navigation, destination interpretation, route planning, and access to relevant tourism information. In addition, the study's findings are expected to contribute to the development of targeted business strategies for travel and tour agencies. These strategies can leverage AR mobile apps to deliver enhanced, innovative, and entertaining tourism experiences and provide more comprehensive and up-to-date information to tourists about historical and cultural places. Furthermore, the ongoing integration of AI with AR mobile app adaptations for historical sites aligns with evolving technological trends and tourist expectations, thereby influencing consumer behaviour and entertainment preferences.

Second, app developers should enhance the interactivity of AR tourism mobile apps. Features such as clickable destination points, suggested routes, cultural information, audio explanations, visual overlays, interactive maps, and user feedback options may enhance tourist engagement. For heritage and cultural sites, AR-based content should include historically accurate storytelling,



visual reconstruction, and context-specific explanations. The seamless integration of AI with AR mobile app development is essential for travel and tour agencies to adapt to evolving technological landscapes and shifting tourist preferences, thereby influencing consumer behaviour and booking decisions. For technology developers and innovators, the findings from the present study highlight a substantial opportunity to capitalise on the burgeoning demand for AR mobile apps within the tourism industry. In addition, collaborating with tourism stakeholders to co-create AR solutions can lead to innovative products and services that enhance visitor experiences and contribute to tourism industry growth.

Lastly, the study's implications extend to the academic community and researchers, contributing to research on technology-mediated tourism experiences and consumer behaviour. Notably, a comprehensive conceptual framework that draws on the promotion of historical places through AR mobile apps, perceived usefulness, satisfaction, expectation confirmation, and continued usage among tourists within the context of smart tourism; previously, researchers had overlooked these aspects, particularly in the travel and tour industry. Therefore, businesses in the travel and tourism, mobile app development, and marketing sectors should use the study's findings to inform their mobile strategies and app development. Thus, such advanced approaches can encourage visitors to fully leverage the unique features and capabilities of AR mobile apps when exploring historical and cultural sites. The AR tourism mobile app should be adapted to Pakistan's local context. Multilingual support, culturally relevant content, offline usability, safety information, and guidance for rural or mountain destinations can improve the overall tourist experience. Collaboration among tourism departments, travel agencies, cultural heritage authorities, and app developers can help create AR experiences that are both technologically useful and culturally meaningful.

5.3. Limitations and future direction

Given the significant findings of this study, several limitations and future research directions are outlined below to strengthen the broader adoption of AR mobile apps, particularly in developing countries. First, to further validate the study's findings, additional data should be collected from diverse visitor segments, including domestic and international tourists, to assess the consistency of correlations across various demographic factors such as income level, residency status, gender, and family composition. This study provides essential information by suggesting that factors such as AR mobile apps directly influence continuance intention to use; therefore, perceived usefulness, satisfaction, and expectation confirmation may not directly affect tourists' continuance usage intention in Pakistan. In addition, the proposed model follows the logic of the expectation-confirmation model, in which the confirmation of expectations primarily influences continuance usage intention through satisfaction. In this view, confirmation is a cognitive comparison between expectations and experience, whereas satisfaction is the affective post-use evaluation that more directly shapes future behavioural intention. Therefore, the present study did not include this direct path because the model focused on the mediating role. Future research may compare alternative model specifications by testing both the indirect pathway through satisfaction and the direct pathway from confirmation of expectations to continuance usage intention in AR tourism contexts.

Second, ethnographic research across diverse countries is essential for identifying cultural variations in AR mobile app usage and facilitating cross-cultural comparisons. The users' cultural context might help establish a suitable environment for developing and establishing such AR mobile apps. Understanding users' cultural backgrounds is crucial for creating effective AR mobile apps. This knowledge can inform the development of culturally appropriate and engaging AR experiences. Future research should examine diverse cultural contexts to validate the proposed framework further and incorporate a broader range of outcome measures relevant to the proposed behavioural model. This might benefit travel and tour agencies, marketing agencies, and mobile app developers who focus on producing multicultural entertainment applications. Undoubtedly, AR technology is poised to significantly impact tourists' experiences in historical and cultural places globally in the near future. Finally, we contextualised the factors within the tour and travel environment, carefully selecting the most relevant based on a comprehensive literature review and expert consultation. Nevertheless, future research should consider additional variables pertinent to specific contexts.

Third, a further limitation of this study is its restricted focus on Google AR Maps. Although Google AR Maps provides a practical and widely accessible example of AR-supported mobile navigation, it does not represent all AR tourism applications. AR technologies differ in their purpose, design, level of immersion, content type, and interaction features. For example, museum-based AR, heritage reconstruction apps, gamified AR tourism apps, wearable AR, and fully immersive AR systems may produce different tourist responses. Therefore, the findings of this study should be interpreted within the context of AR-supported navigation and destination assistance. Future research should compare multiple AR applications across different tourism contexts to improve generalizability and provide a broader understanding of AR-supported tourist experience.



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Appendix 1: Summary of Augmented Reality studies

Author (s) (Year)	Focus	Methodology	Country	Key Findings	Future Direction
Song et al. (2024)	Adoption of mobile AR in tourism	Quantitative study using SEM	Malaysia	Interactivity, vividness, and information content positively affect perceived usefulness and perceived ease of use, which subsequently influence customer engagement, behavioural intention to use, and usage behaviour.	Explore AR adoption in underrepresented regions and examine long-term impacts on tourism behaviours.
Dieck et al. (2024)	AR marketing strategies in hospitality and tourism	Literature review and framework proposal	Global	Proposes a framework based on '4Cs' (consumer, content, context, computing device) for successful AR integration.	Develop AR applications with advanced spatial computing and tailor AR to diverse tourism needs.
Dağ et al. (2024)	Impact of AR on immersive experiences, engagement, and perceived authenticity in cultural tourism	Survey and PLS analysis with 397 participants	Turkey	AR enhances immersive experiences, perceived authenticity, and engagement, leading to higher place satisfaction.	Incorporate diverse AR functionalities for broader museum and cultural applications.
Leou and Wang (2023)	Predicting yoga tourists' revisit intention using TPB and ECM models	Survey and SEM	India	Cultural and spiritual experiences influence satisfaction and behaviour intention; expectation confirmation mediates satisfaction and revisits intention.	Examine other wellness tourism types using integrated behavioural models.



Author (s) (Year)	Focus	Methodology	Country	Key Findings	Future Direction
Ariza-Colpas et al. (2023)	Bibliometric analysis of AR trends in post-COVID tourism	Scientometric analysis of 997 publications	Global	AR promotes sustainable and immersive tourism, especially in a post-COVID era.	Integrate AR with AI for improved user experiences and explore its role in environmental sustainability.
Jiang et al. (2022)	AR and its impact on memorable tourism experiences at heritage sites	A quasi-experimental design with a pre-post survey (n=275)	China	AR enhances MTE dimensions, satisfaction, and behavioural intention. MTE mediates tourist attitudes and intentions.	Explore the long-term impacts of AR on tourism behaviour and expand to different heritage contexts.
Branstrator et al. (2022)	Use of extended reality (XR) in human-wildlife relationships for biocultural conservation	Conceptual framework and case study	USA	XR supports human-wildlife coexistence through critical thinking and immersive education in nature-based tourism.	Expand XR applications to other biocultural conservation initiatives globally.
Yin et al. (2021)	Mobile AR heritage applications for enhancing tourist experiences	Grounded theory approach with in-depth interviews (n=50)	Macau	Identified user needs such as simplicity, relevance, and personalization; emphasized co-creation with tourists.	Develop AR applications tailored to Asian markets and assess their impact on heritage site experiences.
Orús et al. (2021)	Impact of content and device type on customer experience in AR/VR	Lab experiment comparing content realism and device embodiment	Spain	High-realism content and head-mounted displays enhance presence, imagination, and booking intention.	Investigate cross-cultural differences in AR/VR adoption in the hospitality sector.
Olya et al. (2020)	Visitor engagement at science festivals using AR	Asymmetrical modelling using fsQCA	United Kingdom	Aesthetics, education, entertainment, and satisfaction are critical for high visitor engagement.	Broaden the application of AR in diverse festival types and assess its impact on visitor loyalty.
Serravalle et al. (2019)	Multi-stakeholder analysis of AR applications in museums	Conceptual model development based on literature review	Global	Identified the potential of AR in enhancing museum visits through stakeholder co-creation, offering diverse value forms like cultural and educational.	Test the conceptual model in real-world museum settings and explore long-term stakeholder engagement.
Jung et al. (2018)	Cross-cultural differences in AR adoption at cultural heritage sites	Survey and PLS analysis	South Korea and Ireland	Aesthetics strongly influence enjoyment; cultural traits affect AR acceptance differently across countries.	Develop AR designs tailored to cultural contexts to improve global adoption rates.
Han et al. (2018)	Enhancing visitor experience in cultural tourism using VR and AR	A conceptual framework based on prior research and theoretical analysis	Netherlands	AR and VR significantly influence tourists' learning and emotional connection with cultural heritage.	Develop AR and VR technologies for seamless integration into cultural tourism experiences to maximize learning impact.
Fenu and Pittarello (2018)	AR applications for engaging visitors in literary museums	Experimental design with pilot studies (n=48)	Italy	AR and storytelling enhance cognitive and emotional engagement in literary museums.	Expand AR experiences to other literary museums and explore their impact on senior visitors.