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IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

Received 6 March 2025, accepted 13 April 2025, date of publication 18 April 2025, date of current version 30 April 2025.

Digital Object Identifier 10.1109/ACCESS.2025.3562383

RESEARCH ARTICLE

Technology Anxiety in Virtual Reality Adoption: Examining the Impact of Age, Past Experience, and Cybersickness

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This work was supported by the Open Access Funding provided by the University of Essex.

This work involved human subjects or animals in its research. Approval of all ethical and experimental procedures and protocols was granted by the Research Ethics Committee at the University of Essex.

ABSTRACT This study examines the role of Technology Anxiety (TA), age, past use, and cybersickness in the adoption of Virtual Reality (VR) technology. Using an extended Technology Acceptance Model (TAM), the research integrates age and past use as antecedents of TA and evaluates their influence on perceived ease of use (PEoU), perceived enjoyment (PENJ), and user attitudes. Data from 206 participants were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) following a VR pilgrimage experience. The findings challenge conventional assumptions, revealing that past VR use increased TA, contradicting prior studies that associate familiarity with reduced anxiety. Additionally, older users exhibited lower TA levels than younger participants, highlighting a potential shift in how age influences technology adoption. TA significantly enhanced PENJ, indicating that anxiety may amplify emotional engagement in immersive settings, rather than solely acting as a barrier. While TA enhanced PEoU, it had a negative correlation with cybersickness, suggesting that anxious users might interact with VR more cautiously, thereby limiting sensory mismatches. Moreover, cybersickness did not significantly influence attitudes toward the system, emphasizing the dominance of engagement over physical discomfort in emotionally significant experiences. Attitude toward the system strongly predicted use intention, highlighting the necessity of designing VR experiences that balance usability with emotional engagement. This study provides new insights into the psychological and demographic factors influencing VR adoption and offers practical strategies for optimizing user experience, particularly in religious and cultural applications.

INDEX TERMS Age and technology use, cybersickness impact, technology anxiety, virtual reality adoption.

The associate editor coordinating the review of this manuscript and approving it for publication was Laxmisha Rai.

I. INTRODUCTION

The information and communication technology (ICT) has revolutionised marketing practices; it offers innovative media platforms to promote products and services [1]. The use of virtual environments (virtual reality and augmented reality) in marketing has increased massively significantly [2] as it focuses on creating remarkable, innovative, immersive experiences and lasting memories [2]. The virtual environments market is expected to generate revenues of US$40 billion in 2024 and is expected to reach US$ 62 billion by 2029 [3]. Virtual reality's (VR) capability to visualize spatial depth makes it an effective marketing tool for intangible experiential products such as tourism [4], ranging from; cruises, theme parks, destinations, and museums. It was found that providing travel-related information to potential travellers through an immersive VR destination experience enhances the intention to visit; it also helps potential travellers to make informed travel decisions by enabling interaction and comparison between destinations [5]. In addition, VR experiences can enhance destination image and increase visitor intention [6]. Moreover, VR can provide access to remote or fragile environments without physical impact, promoting sustainable tourism practices [7]. As VR technology continues to evolve, its applications are expanding, offering innovative ways to attract and engage users in various industries, including tourism [8].

Customer's reliance on ICT has transformed the way people plan and experience their travel and make travel decisions. Immersive VR tours generate greater interest in destinations and assist in more informed decision-making [6]. For instance, exploring rooms and amenities hotels and resorts offer increases customer engagement and booking rates [9]. Also, VR makes travel experiences more accessible for people with mobility challenges, allowing them to virtually experience the destinations and giving them more travel options [10].

The application of VR in tourism marketing has been the focus of many studies, for instance, [6], [9], [10], [11], [12]. Most studies investigating VR's application in tourism have relied on the Technology Acceptance Model (TAM) to identify the determinants of VR acceptance in tourism. However, to the researcher's knowledge, no studies have investigated significant factors such as age and past use of VR in addition to technological anxiety (TA) and how it impacts the acceptance of VR in tourism. This study aims to fill a gap in the literature by extending the TAM by incorporating age, past use, and cybersickness as factors contributing to the intention to use VR, particularly in emotionally and culturally significant contexts. Also, it measures the role that TA plays in shaping both cognitive and emotional responses to VR, showing that anxiety can detract from ease of use and enjoyment while simultaneously heightening emotional engagement in some cases. This study has been applied to the context of religious pilgrimage. The motivation for religious tourism is to fulfil personal values across physical, spiritual, emotional and intellectual levels [13]. The study uses the VR tool to simulate the experience of Umrah rituals, guiding users through the different steps of the Umrah journey. The experience begins with the user's arrival at the airport, followed by a virtual visit to a hotel, preparations at the 'miqat' point (a designated location where pilgrims enter the sacred state of Ihram before performing Umrah), and, finally, a digital journey to the Masjid Al-Haram. The research questions are:

RQ1: How do age and past use influence the level of technology anxiety experienced by users in VR environments?

RQ2: What is the relationship between technology anxiety and user attitudes toward VR, and how do factors such as perceived ease of use and perceived enjoyment influence this relationship?

This study introduces several key innovations that contribute to advancing the literature on technology adoption in immersive environments. It extends the traditional Technology Acceptance Model (TAM) by integrating psychological and emotional dimensions, most notably by incorporating TA as a central construct. Additionally, the study introduces age and past VR use as antecedents of TA, offering a more refined understanding of how demographic and experiential factors influence user acceptance. Another notable contribution lies in the inclusion of cybersickness as a physical and sensory variable affecting users' attitudes toward VR—an aspect frequently overlooked in previous TAM-based research. Uniquely, this work situates the investigation within a religious and culturally significant setting, thereby addressing VR adoption in emotionally intensive use cases, which are underrepresented in the literature. Methodologically, the study employs an integrated framework combining TAM with the Technology Readiness Index (TRI 2.0), and applies Partial Least Squares Structural Equation Modelling (PLS-SEM), thus enhancing the analytical depth and theoretical robustness of the findings.

This paper begins by introducing the phenomenon of VR and outlining its capabilities and significance. It then presents the theoretical framework and hypothesis development, providing a comprehensive understanding of the key constructs, their interrelationships, and the barriers influencing user acceptance of VR in tourism-related activities. The methodology section details the research design, data collection procedures, and analytical techniques employed. This is followed by the analysis, which presents the research findings and tests the proposed hypotheses. The conclusion and discussion section synthesises the key insights and highlights their broader implications. The limitations section acknowledges the study's constraints and suggests directions for future research. Finally, the contribution and future research section elaborates on the study's theoretical and practical contributions while proposing avenues for further scholarly exploration in this domain.

II. VIRTUAL REALITY CONCEPT

Virtual reality (VR) is a technology that creates an interactive, three-dimensional environment with a sense of spatial presence [14]. While often defined by hardware, VR can be conceptualized through dimensions of telepresence, particularly vividness and interactivity [15]. It allows users to interact with computer-simulated environments, ranging from real-world simulations to imaginary worlds [16]. Recent advancements in digital twin and mixed reality (MR) technologies have further enhanced the role of VR in fields such as education, training, and collaborative environments. Digital twin technology, when integrated with MR, enables real-time simulation and monitoring, creating immersive and interactive training experiences that closely replicate real-world scenarios [17]. These applications offer significant benefits in education and industrial training, allowing for better visualisation, real-time data integration, and more effective decision-making processes.

In addition to its growing applications in education and training, VR has also gained significant traction in tourism. Improvements in computational power and the availability of affordable VR devices have contributed to the increasing use of VR in the tourism sector [9]. Recent research highlights the growing impact of VR and wearable devices in tourism. VR tours offer immersive experiences that can influence tourists' behaviour and intentions to visit physical locations [18]. These technologies enhance tourists' engagement and evoke positive emotional reactions, particularly when compared to traditional devices like desktop computers and mobile phones [19].

Wearable devices have become a cornerstone of VR technology, enhancing user immersion through devices such as head-mounted displays (HMDs), haptic gloves, and motion trackers [20]. HMDs like the Oculus Rift and HTC Vive provide stereoscopic 3D visuals and head tracking, enabling users to look around virtual environments naturally [21]. Haptic feedback devices offer tactile sensations, allowing users to feel virtual objects and enhancing their sense of presence [22]. Wearable devices are predicted to streamline how tourists interact with stakeholders and their environment, although research on their application in tourism is still limited [23].

In the context of tourism, VR applications have emerged as powerful tools for marketing and destination promotion [24]. VR enables potential tourists to experience virtual tours of destinations, influencing their travel decisions [6]. The recent impact of VR on tourism is significant, as it allows for personalized and interactive experiences that engage potential travellers [25]. The immersive nature of VR can evoke emotional responses and create memorable experiences, which are crucial factors in destination marketing [26].

In addition to marketing and pre-visit experiences, VR has been employed to create historical environments from anywhere in the world [27]. Furthermore, VR tourism experiences have been instrumental during situations where physical travel is restricted, such as during the COVID-19 pandemic, providing alternative means for people to explore destinations virtually [28]. VR can also cater to niche markets by offering extreme tourism experiences, like virtual skydiving or deep-sea diving, which may be inaccessible or risky for some individuals [29]. As VR technology becomes more sophisticated, integrating with other emerging technologies like artificial intelligence and the Internet of Things can create more immersive and personalised tourism experiences [30]. This synergy of technologies is anticipated to revolutionise the tourism industry by enhancing customer engagement and satisfaction [31].

III. THEORETICAL FRAMEWORK

To obtain a comprehensive understanding of the barriers shaping user acceptance of VR in tourism-related activities, our research draws on a theoretical framework incorporating a model and a theory. This multidisciplinary foundation is not new; it has previously been enhanced to conduct a comprehensive investigation into how various factors contribute to the adoption and integration of new technologies. Scholars [32] used the UTAUT2 model, which combines the Theory of Reasoned Action [33], the Theory of Planned Behaviour [34], and the Technology Acceptance Model [35], to investigate Artificial Intelligence (AI) and consumer behaviour. Similarly, a study [36] combined the Technology Readiness Index [37] with the TAM [35] to examine the positive behavioural impacts of screen golf and virtual reality sports games. Other scholars [38] based their study on three well-established theories within the service robots' literature: the Technology Readiness Index 2.0 [39], Cognitive Appraisal Theory [40], and Attachment Theory [41].

In VR research, different theoretical models have been applied based on the study domain. The Information System (IS) model integrates system design and usability to assess the effectiveness of VR interfaces [42]. A broader approach is taken by the Stimulus-Organism-Response (S-O-R) model [43], [44], which explains how VR stimuli influence user emotions and behaviours, supporting research on VR-induced emotional and cognitive states. Furthermore, the TAM [44], [45], [46] remains one of the most widely applied frameworks, particularly in assessing Perceived Ease of Use (PEoU) and Perceived Usefulness (PU) in VR adoption.

Beyond system usability, VR adoption extends to consumer engagement, marketing, and virtual shopping. Several consumer behaviour theories have been employed to understand how VR influences purchasing decisions and user experiences. The Theory on Consumer Learning [47] explores how VR-based interactions shape consumer knowledge and decision-making. The Unified Theory of Acceptance and Use of Technology (UTAUT) [48] expands on TAM, incorporating social influence, effort expectancy, and performance expectancy into VR adoption. The Expectancy Theory [49] suggests that users engage with VR when they perceive a direct benefit or reward. Additionally, the Self-Brand Connection [50] framework explains how VR can enhance emotional connections with brands, making it an effective tool for immersive marketing and branding strategies.

The theoretical foundation of this study is based on the TAM [35] and the TRI 2.0 [39]. These models can identify the emotional and psychological barriers that may affect VR adoption. First, TAM is still the most widely used model for understanding user acceptance [36], [51], [52] and has received significant empirical support. In this study, the TAM variables used are ease of use, attitude towards the system, and use intention. Second, scholars [39] defined TRI as a set of psychological motivators and inhibitors that influence an individual's willingness to adopt new technology. TRI has four dimensions: two motivators (optimism and innovativeness) and two inhibitors (discomfort and insecurity). The current study only used inhibitors and combined them into a single construct called technology anxiety. Technology anxiety encompasses the essence of both discomfort and insecurity in order to reflect users' unease and apprehension when faced with new technologies. This allows for a more effective capture of general perceptions of technology that may affect individuals' anxiety and attitudes towards adopting innovations like VR. To improve our model's predictive ability, the study expands the framework to include two individual differences (past use and age) and two external factors (enjoyment and cybersickness). This study follows the lines of prior studies that have extended models to fit different technologies [53], different contexts [54], and different users [55].

A. PAST USE

Past use or experience with technology is particularly salient in the study of its adoption and use [56]. Humans are instinctive to categorise and classify objects, including technologies, based on their experiences [57], [58]. This can be derived from cultural experiences, including geographic locations, religious and political circumstances, as well as popular culture, including art, literature, television, and film [59], [60]. These experiences can instil either positive or negative perceptions, expectations, anxieties toward and behavioural intentions to use a technology or system [56], [60]. Experience using a technology or system has a strong influencing capacity over the user's perceptions, dampening anxiety, hesitancy, and resistance, predicting greater behavioural intention to adopt and use [61], [62]. If an individual has personally used technology or views others successfully navigating a technology within their social circle, the likelihood for them to adopt and use the technology themselves is greater [63]. Past use of technology is tied to the development of self-efficacy, whereby an individual builds skills and belief in those skills to successfully operate a technology [63], [64]. Consistent with [64], the effect of past use or experience with a technology or system is '*positively correlated with improved user perceptions, beliefs, and automatic behaviours to continue use*' (p.4). This is underpinned by the expansive theoretical literature, primarily the 'Diffusion of Innovation Theory' (DIT) popularised by [65] and [66], theorised that the key component of 'compatibility' in his model was supported by a user's experiences, which predicated greater rates at which a technology or system would be adopted by users.

Experience is a concept of interest in the study of the adoption and use of VR technologies, which is similarly emerging. Consistent with [67], a systematic review illustrates that user perceptions of VR shifted from a 'generally negative impression of the technology before use changing to a generally positive impression after use' [67]. This is supported by [68], whose empirical evaluation of South Korean consumers indicated that the likelihood of purchasing VR technology was greater if they had some experience with the technology. This included experience in advertising and marketing campaigns or inter-social groups [68], [69]. Building upon this consumer perspective, researchers indicated that past use of VR technologies as purchasing predictors for greater adoption and use [64], [70]. This is supported by [71] and [72], who found greater adoption rates of VR for each instance an individual used the technology. Similar findings regarding past use or experience with VR technologies, future use intention, perceived ease of use, and anxiety surrounding its use were found by [70]. They found that the theoretical hypothesis supported the systematic review findings regarding users' past experiences with VR technology and its impact on future usage intention, demonstrating that it had a significantly positive effect on the user's perceived ease of use and a reasonable significance on future usage intention [64], [73], [74]. These dimensions directly influence a user's anxiety, hesitancy, or resistance to trying or using VR again. Furthermore, the review found that users' anxiety about VR technology was significantly dampened with each use, beginning with the first, whereby requisite skills and self-efficacy were built [70], [73]. Subsequently, past use or experience has a direct and positive effect in reducing technology anxiety, increasing adoption, and continued use. This was similarly found for VR technologies. Drawing from the reviewed studies, we propose the hypothesis that Past Use has a direct effect on TA.

H1. Past Use has a direct and negative effect on Technology Anxiety.

B. AGE

Research studying the interactions between individuals and technology by age group and life stages is well-versed [56]. Age and life stage differences are well established and understood in what will drive technology acceptance and use by individuals [75]. Divided by sub-demographics worldwide, older adults are more averse, anxious toward, hesitant, and resistant to newer forms of technology [56]. Older adults' formative years and developmental environments had fewer modern technologies. This can drive negative perceptions of technology, including fear or anxiety of perceived change, difficulty operating the technologies and lack of experience building. This lack of experience drives an inability to form self-efficacy with technologies, contributing to their anxieties, averseness, and resistance [63], [76], [77]. Older adults in later life stages have usually formed a stable sense of identity, making them less influenced by their peers and, thus, less likely to try, adopt and use newer forms of technologies [78]. Comparatively, younger people are more open and accepting of technologies, perceiving them as more valuable and useful [56], [62]. Ordinarily, their formative years and developmental environment were rich, with newer forms of technologies developing alongside them [75]. Younger people in earlier life stages are also more prone to outside social influences, such as technology marketing and peers, making them less anxious or resistant to technology and thus more likely to adopt and use it [75], [76]. Conventionally, this phenomenon is referred to as a 'digital divide' [64]. A 'digital divide' refers to a gap in technology acceptance and use, whereby younger generations are increasingly exposed to digital technologies in their formative and developmental years, building experience, learning, and growing alongside the technologies [64], [79]. In comparison, older adults are exposed to these newer forms of digital technologies at much later life stages, missing the learning and developmental experiences in their formative years [64], [75], [79]. Subsequently, this drives older adults to be more hesitant or anxious to try digital technologies and more resistant to their continued use [56], [61].

The 'digital divide' phenomenon regarding VR technologies is similarly emerging in the literature. As found by [64], there is a significant negative relationship between increasing age and perceptions of VR technology and 'this negative relationship indicates the older the consumer, the less likely they will perceive VR hardware easy to use' [64]. This is supported by [36], who highlighted the negative relationship that was associated with age and enjoyment of VR experiences. A surprising finding from this study indicated that older adults' negative perceptions of VR were lesser than those of other technologies. Conversely, findings by [67] in a systematic review illustrate a difference between older adults' perceptions of VR before and after use, noting that they had a 'generally negative impression of the technology before use changing to a generally positive impression after use' [67]. This review indicated that the perceptions of older adults toward VR shift if they trial the technology [67]. Furthermore, these findings suggest that modifications and customisation of VR toward older adults specifically could improve older adult user perceptions, experiences, adoption, and continued use [56], [67]. Subsequently, age has a direct and negative effect on technology anxiety, adoption, and use. Drawing from the reviewed studies, we propose the hypothesis that Age has a direct effect on Technology Anxiety.

H2. Age has a direct and negative effect on Technology Anxiety.

C. TECHNOLOGY ANXIETY

TA has been a central theme in technology adoption studies for decades, significantly influencing users' perceptions, interactions, and eventual acceptance of new technologies. TA denotes the adverse emotional reactions that individuals encounter when interacting with technology, including fear, apprehension, and discomfort. These emotions can impede users' confidence, competence, and willingness to engage with new technology, frequently leading to reduced engagement or complete avoidance [80]. As digital systems have evolved—spanning traditional computing to more immersive platforms such as VR and augmented reality (AR)—the role of TA has expanded to accommodate the complexities introduced by modern technologies.

As immersive platforms like VR have grown in popularity, the significance of TA in these environments has become more pronounced. VR systems require users to interact with complex, multi-sensory environments, often in real-time, which can amplify feelings of discomfort and anxiety [81]. VR presents unique challenges, such as motion sickness, spatial disorientation, and sensorimotor demands, which can exacerbate TA.

Recent studies have explored the effects of VR on anxiety and related experiences. While prolonged VR use does not appear to cause long-term depersonalization/derealization symptoms in most users, younger female users and those experiencing higher levels of embodiment may be more susceptible [82]. The immersive nature of VR can overwhelm users, leading to heightened anxiety [83]. Additionally, the "unfamiliarity paradox" described by [84] suggests that users unfamiliar with VR interfaces report higher anxiety due to perceived loss of control in virtual environments. A study by [85] demonstrated that poorly designed VR headsets caused neck strain and eye fatigue, which correlated with increased self-reported anxiety. Despite the fact that technology anxiety can be a barrier, particularly for elderly users who may experience fear and hesitation when confronted with VR equipment [86], research suggests that preparatory exercises and acclimatization techniques may help overcome this technology rejection in older populations. VR-based tools can provide valuable insights into social anxiety through the analysis of sensor data and mediating variables, such as self-presentation motivation and self-focused attention [87]. On the contrary, VR technology shows promise in addressing anxiety disorders, with studies demonstrating its potential to reduce anxiety levels through immersive experiences [88], [89]. These studies highlight the importance of considering user experience, immersion, and individual differences when designing VR interventions for different purposes.

TA in VR can significantly affect Perceived Ease of Use, as users may struggle to navigate virtual spaces or operate VR equipment, leading to frustration and disengagement. Researchers found that anxiety fully mediated the relationship between system experience and PEoU, suggesting that reducing anxiety is critical to improving users' perceptions of ease of use in immersive systems [90]. Furthermore, the cognitive demands of VR may cause anxious users to view the system as overly complex, directly impacting their willingness to engage with it [91].

Furthermore, scholars investigated the impact of stereotype threat—the fear of confirming negative stereotypes of one's social group—on technology adoption among older persons [80]. They found that anxiety mediated the relationship between stereotype threat and PEoU, particularly in VR contexts where the cognitive and physical demands are heightened. This underscores the broader ramifications of TA among various user demographics, indicating that measures designed to alleviate anxiety and stereotype threat may improve the accessibility and functionality of VR technologies.

The relationship between TA and perceived ease of use (PEoU), perceived enjoyment (PENJ), and perceived usefulness (PU) in immersive systems such as virtual reality is a significant topic for further study. Although considerable knowledge exists on TA's impact on conventional systems, the specific mechanisms by which anxiety affects cybersickness, sensorimotor demands, and spatial disorientation in virtual reality environments are poorly examined. Furthermore, individual characteristics such as self-efficacy, stereotype threat, and prior experience may play critical roles in moderating the effects of TA in VR settings.

Early research, particularly within the framework of the TAM, focused on the role of PEoU and PU in explaining technology adoption [92]. However, TA introduces an additional layer of complexity, acting as a barrier to PEoU and PU. While a significant body of research has examined TA's influence on PEoU, its impact on PU and PENJ—especially in immersive environments like VR—remains underexplored, presenting opportunities for further investigation.

Studies have consistently shown that TA adversely affects novel technologies' PEoU [93]. Individuals with elevated anxiety levels regard systems as more challenging to learn and operate, resulting in less confidence in their technological proficiency [94]. This supports the notion that TA directly affects PEoU. The correlation between technology acceptance and PEoU is notably apparent during initial interactions with novel technologies, as inexperienced users may experience fear of unfamiliar interfaces and functionality [95].

TA significantly influences the cognitive and emotional resources users dedicate to engaging with technology. Individuals with anxiety are more inclined to view systems as excessively complex, resulting in increased cognitive load and frustration [94]. This effect is especially evident in settings requiring users to learn new skills, such as VR. TA can markedly diminish PEoU in these contexts, hampering the adoption process. It was asserted that designers and developers can mitigate this adverse effect by enhancing user interface designs and implementing focused training interventions, which may diminish fear and bolster confidence [62]. Therefore, it was hypothesised the following:

H3. Technology Anxiety has a direct and negative effect on Perceived Ease of Use.

The correlation between TA and perceived enjoyment is intricate and contingent upon context. Perceived Enjoyment refers to users' enjoyment or satisfaction from engaging with a system independent of its functionality [96]. TA can reduce Enjoyment by increasing cognitive load and emotional strain, making the user experience less favourable [81]. In immersive technologies such as VR, where the user experience is highly interactive and sensory-rich, anxiety can detract from enjoyment, leading users to disengage prematurely.

The role of technology anxiety was examined in mobile payment services and it found that higher levels of anxiety negatively impact users' enjoyment of the technology, limiting their willingness to engage with it [97]. Their findings suggest that technology-induced stress increases cognitive load, which in turn reduces the perceived enjoyment of interactive systems. While enjoyment is a key driver for adoption, anxiety acts as a psychological barrier, making users less inclined to explore and benefit from the immersive or hedonic aspects of the technology. This insight aligns with existing research in VR adoption, where users with heightened technology anxiety report lower levels of enjoyment due to cognitive overload and usability concerns. Scholars examined the moderating role of TA in mobile AR applications [81]. They found that users with higher anxiety levels were less likely to enjoy immersive experiences, suggesting that this negative relationship may extend to other immersive systems like VR. Hence, it was hypothesised the following:

H4. Technology Anxiety has a direct and negative effect on Perceived Enjoyment.

Research suggests a complex relationship between technology anxiety and cybersickness in VR context. Anxiety has been found to partially mediate cybersickness symptoms, particularly nausea and disorientation [98]. Both state and trait anxiety positively correlate with disorientation symptoms after VR exposure [99]. However, the relationship between presence and cybersickness is generally negative, driven by sensory integration processes [100]. Importantly, measures of anxiety and cybersickness may be confounded due to overlapping questionnaire items, as evidenced by correlations between anxiety levels and nausea subscales in non-cybersickness-inducing environments [101]. Gender differences in cybersickness symptoms have been observed, though these may be present before VR exposure [98]. Past VR experience does not appear to influence the severity of cybersickness [99]. These findings highlight the need for improved measurement specificity and further research to disentangle the effects of technology anxiety on cybersickness during VR headset use. Given the limited empirical evidence clarifying whether a direct relationship exists—and if so, the nature of its directionality—the following hypothesis was proposed:

H5. Technology Anxiety has a direct and positive effect on Cybersickness.

D. PERCEIVED EASE OF USE

PEoU refers to how an individual believes that using technology is simple and effortless [35]. This concept has been examined in various models, including the UTAUT [54] and the Innovation Diffusion Theory [102]. VR's user-friendliness has been emphasised in previous research. Natural gestures and voice commands make virtual environment interaction more intuitive and seamless and reduce the need for complex control schemes. Advanced motion tracking accurately reflects users' physical movements in the virtual space to be more engaging and responsive. Modern VR systems need little space, allowing users to enjoy VR experiences even in small spaces. VR's 3D visualisation makes virtual interactions more realistic and engaging [53], [103], [104]. These features promote VR in tourism activities such as travel, information exploration, viewing photos and holographic images, gaming, 3D 360-degree viewing, and drone videos [11], [36]. Users may expect that VR requires no more effort than other immersive technologies used in tourism. Users are more likely to use technology that is easy and simple. Thus, it could be argued that VR's PEoU boosts users' positive attitudes..Davis [35] was the first to demonstrate this relationship in the TAM, and it has since been validated [64], [105]. As a result, the formulated hypothesis is:

H6. Perceived Ease of Use has a direct positive effect on Attitude Towards System

E. PERCEIVED ENJOYMENT

PENJ is "the activity of using a specific system that is perceived to be enjoyable" [61]. Much of the previous research has examined PENJ in computer gaming [106], information systems and e-learning [107], online shopping and instant messaging services [108], and travelling [109]. PENJ of VR could be due to immersion that makes users feel they are "inside" and "being here" in the virtual environment, along with 3D visualisation and interaction that provide users with a sense of reality and experience with such an environment [6]. Some studies have linked PENJ in VR technology with attitude; for example, scholars found that consumer perception of PENJ was a key belief variable impacting motivation to use VR and thus influencing behavioural intention [64]. According to [6], tourists who enjoyed a VR experience had a more positive attitude toward the destination, which increased their travel intention. Also, PENJ of VR was examined on attitude for learning and training purposes, and the results were positive [105]. These views were insightful because they imply that users will be more likely to use VR if it provides pleasure, fun, and satisfaction. PENJ is an internal motive to use VR and may shape an effective experience with it. A lack of enjoyment may give the impression that using the system is more difficult and unpleasant. Therefore, this research proposes the following hypothesis:

H7. Perceived Enjoyment has a direct and positive effect on Attitude Towards System

F. CYBERSICKNESS

Cybersickness is conventionally thought of as a modern phenomenon and a consequence of modern VR technology. However, it traces its origins to earlier technologies, including military flight simulators and early gaming systems [110]. Cybersickness occurs when individuals exposed to a virtual environment experience symptoms commensurate with motion sickness [111]. This can include disorientation, fever, fatigue, nausea, and eye, ear, and head straining caused by inputs and outputs of the virtual environment [111]. In earlier virtual technologies, such as military flight simulators, it was found that cybersickness significantly affected pilot training, reducing training time, efficiency, and overall safety [110]. Furthermore, this type of cybersickness tarnished training pilots' attitudes toward flying, leading to a decrease in their overall adoption and use in training settings [110]. This is not limited to this form of virtual technology; in the modern world, significant increases in smartphones, multi-screen laptops, and non-virtual gaming systems have spurred cybersickness incidences [111], [112]. This was significantly heightened during the COVID-19 pandemic with work-from-home mandates, causing some technology users to develop an antipathy toward smartphones, computers and gaming systems, causing cybersickness from continued use [111]. As found by [110], [111], and [112], incidents of cybersickness in existent technologies have profound impacts on users' attitudes toward the technology or system, diminishing their intention to adopt, use and continue using. As technologies become increasingly immersive and virtual, cybersickness incidences are likely to rise, increasing the negative perceptions and attitudes toward technologies like VR [113].

Cybersickness incidents are of primary importance to VR technology users, developers, and programmers [113]. Cybersickness events cause negative perceptions of VR, tarnish experiences and lead to eventual discontinuation. As found in a systematic review of 55 studies on VR technologies, 'VR headsets were associated with more side effects compared to the desktop computer screen [113]. Similar findings were reported by [114] and [115], who highlighted the direness of resolving cybersickness events in VR technologies to garner widespread positive perceptions, adoption, and continued use. Comparatively, the emerging literature on newly developed VR technologies, cybersickness and user attitudes has demonstrated contrary results. As found in studies by [116], [117] and [118], VR technology use among older adults, stroke patients and pilot trainees developed no negative perceptions or attitudes from their experience with VR induced cybersickness. A significant caveat of these findings was the lower reported incidences of VR-induced cybersickness. For example, [116] found '*independence between self-reported discomfort and the participant group for severe, moderate, mild and no complaints'*(p. 4). Subsequently, this review found that cybersickness events are increasingly common with immersive smart technologies and have a significant influence on the development of negative attitudes towards, adoption and use of the system. These findings were corroborated in the earlier literature for VR technologies; however, some emerging studies have demonstrated that cybersickness events have lower impacts on user perceptions and attitudes toward the technology than conventionally considered. This synthesis highlights a divide in the findings, highlighting that VR developers and programmers recognise the issues of cybersickness on user attitudes and perceptions, seeking to reconcile this for greater adoption and use of VR systems. Building on the insights from previous research, we hypothesise that Cybersickness has a direct effect on Attitude towards the system.

H8. Cybersickness has a direct and negative effect on Attitude Towards System

G. ATTITUDE TOWARDS SYSTEM

Departing from a traditionalist perspective of attitudes, which denote either liking or disliking an object, attitudes in a technological adoption space are multi-faceted [119]. This includes individual experiences and past use, age and life stage, perceptions of benefits and ease of use, cultural, political, and historical circumstances and a priori assumptions about technology or systems more broadly [35], [36], [56], [64], [120]. As established in the literature, attitude dimensions are usually unconsciously weighed as a cost-benefit analysis of a technology or system far before an opportunity to use is presented [64]. As found in a meta-analysis of user intentions of technology by [121], a priori attitudes about technology or systems play the role of a 'mediator' in determining their final adoption and use. This highlights that positive or negative user intentions to adopt and use a technology or system are formed far before the opportunity arises. Scholars found that strong positive attitudes toward technology predisposed an individual's intention to use. Conversely, weak or neutral attitudes toward technology had a diminishing effect [122]. Considering an operational definition of attitudes in technology adoption and intention to use, a user's attitudes toward digital technologies and systems have a significant and direct impact on the user's intentions to adopt them [64].

The study of attitudes and their impact on intentions to adopt and use VR is emerging in the literature at pace with the technology's development and diffusion into the population [64]. Consistent with [64] and [121], the cost-benefit imbalance and mediating role of attitudes in intentions to use VR can be profoundly impacted. Namely, users may have pre-conceived attitudes, beliefs or perceptions about VR, which preclude them from adopting, using, and building experience with the technology. As with other dimensions, user experience is imperative to further adoption and use of technology like VR [67]. If users' negative attitudes about VR preclude them from trialling VR, then experience using the system is not obtained, and further adoption and use is unlikely [67]. This is further supported by [123], who found that positive attitudes and perceptions of usefulness regarding VR in education influenced teachers' behavioural intentions to adopt and use VR in their classrooms. As found by [123] 'Attitude towards Technology influenced the behavioural intention to use VR technology' (p.7). This is further supported by [124], whose evaluation of attitudes towards VR was reinforced by perceptions of usefulness. Moreover, 'factors such as perceived usefulness and enjoyment play pivotal roles in shaping users' attitudes and intentions to continue using VR' (p.2) [124]. Therefore, if individuals perceive VR technology as useful, beneficial, easy to use and aesthetically pleasing, it is likely they will have more positive attitudes toward the technology and be likely to adopt it and continue use [124]. Subsequently, this review found that a user's attitudes toward technologies, systems and VR significantly and directly influence their intentions to adopt and use. Finally, positive attitudes predict greater potential adoption and use, negative attitudes predict weaker potential adoption and use. However, as research on the adoption and use of VR is still emerging, one caveat of this synthesis is that negative attitudes may be overcome if there is a requisite perception of the benefits of using VR technology. Considering the reviewed literature, we suggest the hypothesis that the attitude towards system has a direct effect on use intention.

H9. Attitude Towards System has a direct and positive effect on Use Intention

H. USE INTENTION

Use intention refers to an individual's conscious decision/plan to perform or, engage with or use a specific technology or system [34]. It is a key construct in models that study technology acceptance and user intention, for example, the Unified Theory of Acceptance and Use of Technology [54]. Within the realm of technology acceptance, use intention has become a critical construct, often used as a reliable predictor of actual usage. It is widely considered to be one of the most reliable indicators of whether a person will adopt and continue using a technology [35], [54]. In the TAM and VR studies, use intention is often used as the main or even sole measured outcome of interest, highlighting its importance in understanding user intention and technology adoption [36], [64], [105]. Table 1 provide a complete summary of all hypotheses, including the psychological construct, hypothesized influence and the nature of influence.

IV. METHODOLOGY AND RATIONALE

Our constructs were developed based on a comprehensive review of existing literature and various technology adoption theories, as previously discussed. This extensive analysis culminated in the conceptual model illustrated in Fig. 1. To validate this model and its associated hypotheses, established statistical methods were planned for use.

In creating our initial survey tool, we consulted with six experts who have deep expertise in human-computer interaction and information systems, each offering unique insights into fostering the intention to use VR applications in tourism. Among these experts, four were academics with doctorates in relevant fields, while the remaining two were industry professionals with over a decade of experience in research and development, particularly in combating cybercrime. These experts helped refine our initial set of 20 questions, resulting in the exclusion of five due to their unsuitability for producing reliable results or due to clarity and readability concerns. This refinement led to a final set of 19 carefully considered questions covering ten distinct constructs. Of these, three constructs were categorised as 'first order' and were

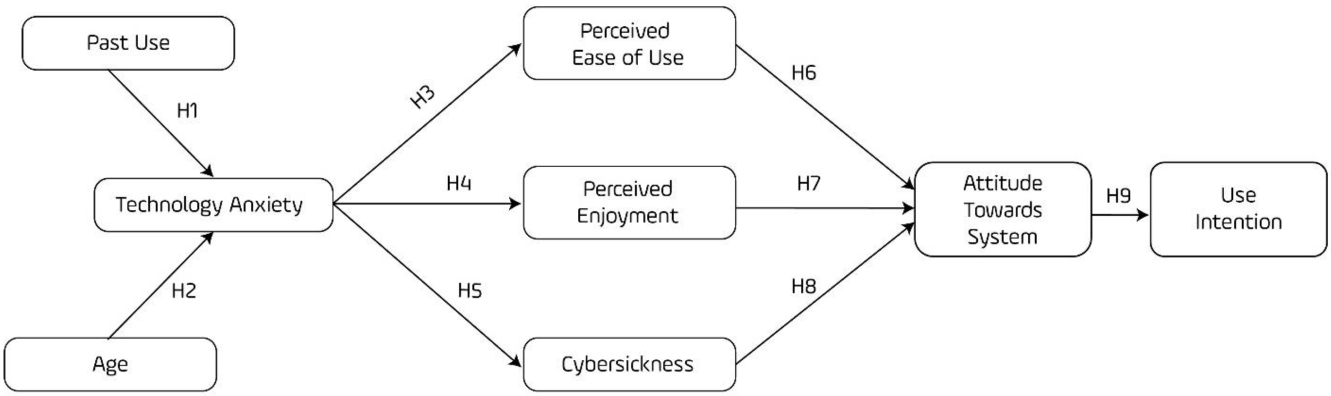

FIGURE 1. Theoretical framework.

combined into a single construct for analysis. The questions were strategically ordered, beginning with simpler ones and gradually progressing to more complex queries. Throughout the questionnaire design process, we adhered to established guidelines, ensuring that layout, design, and clarity were prioritised to avoid any ambiguity. We adapted existing and validated scales to measure the constructs in our model. Detailed information about these questionnaires is provided in Appendix.

The VR tool used in this study was a custom-designed interactive application aimed at stimulating the experience of performing Umrah rituals. The application was meticulously crafted to guide users through the Umrah journey in a series of distinct stages. The experience begins with the user's arrival at the airport, followed by a virtual visit to a hotel, preparations at the miqat point, and, finally, a digital journey to the Masjid Al-Haram. This immersive journey covers all the key rituals associated with Umrah. For hardware, the Meta Quest 2.0 VR headset was selected due to its advanced features. The system was designed to be user-friendly, especially for first-time users, enabling easy navigation within the virtual environment. This was achieved through an intuitive interface that allows for straightforward movement with minimal interaction, as shown in Fig. 2. The primary goal of this VR system was to provide users with a realistic and educational preview of performing Umrah in a virtual setting.

Prior to recruiting participants for the study, ethical approval was secured from the University of Essex. The participants were regular attendees at the Southampton Central Mosque in Southampton, United Kingdom. These individuals were selected based on their regularity in performing the five daily prayers, indicating a high level of religious commitment. A booth, equipped with informative visuals, was set up to attract participants to the VR tour. Regarding the sampling method, participants were chosen from this readily available group due to their relevant religious involvement and potential interest in the VR simulation of Umrah rituals. Participants were invited to engage in the VR experience after completing their daily prayers, capitalising on their presence and availability at the mosque.

This strategy facilitated the efficient recruitment of individuals who were not only consistent in their religious practices but also likely to be interested in religious knowledge, particularly the Umrah pilgrimage. Although the convenience sampling method may limit the generalizability of the findings due to the non-random nature of participant selection, it was deemed suitable for the exploratory focus of this study, which aimed to examine a specific community's interaction with the VR application. A research assistant was employed to invite participants to the VR experience following their prayers. Participants were given a brief training session on using the device, which lasted 5 minutes, followed by a 10-minute experience phase, totalling 15 minutes.

A. SAMPLING AND ANALYSIS

During the initial survey phase, 212 participants were successfully engaged. To accurately measure responses, a five-point Likert scale was utilised, ranging from 1 (strongly disagree) to 5 (strongly agree); detailed information about these questionnaires is provided in Appendix. The VR experience was available for a month, from June to July 2023, to collect sufficient responses. To ensure data integrity, two methods were implemented to filter out invalid responses. First, following the data filtering procedures recommended by [125], we excluded participants who, based on the online tracking system, spent less than five minutes on the survey—a common practice in survey research to ensure respondent engagement and data quality. Additionally, incomplete questionnaires were also excluded, resulting in 206 valid responses.

1) COMMON METHOD VARIANCE

As with all self-reported data collected from individual respondents at a single point in time, there was a risk of common method variance (CMV) and bias [126], [127]. To address this, we implemented both procedural and statistical methods to test for CMV. Initially, we worked with practitioners and academics to carefully refine the survey items, enhancing face validity and reducing ambiguity [128]. We also ensured respondents' anonymity and full

TABLE 1. Hypotheses summary.

Psychological Construct	Hypothesis Number	Hypothesized Influence	Nature of Influence	Nature of Hypothesis
Past Use	H1	PU → TA	Positive/Negative	Extended hypothesis
Age	H2	AGE → TA	Positive/Negative	Extended hypothesis
Technology Anxiety	H3	TA → PEoU	Negative	Extended hypothesis
Technology Anxiety	H4	TA → PENJ	Negative	Extended hypothesis
Technology Anxiety	H5	TA → CS	Positive	Extended hypothesis
Perceived Ease of Use (PEoU)	H6	PEoU → ATS	Positive	Conventional TAM hypothesis
Perceived Enjoyment (PENJ)	H7	PENJ → ATS	Positive	Conventional TAM hypothesis
Cybersickness (CS)	H8	CS → ATS	Negative	Extended hypothesis
Attitude Towards System (ATS)	H9	ATS → UI	Positive	Conventional TAM hypothesis

confidentiality to mitigate social desirability bias and reduce the inclination to provide 'correct' answers [128]. Additionally, we evaluated variance inflation factors (VIFs) as a more rigorous test within partial least squares structural equation modelling (PLS-SEM). VIFs of 3.57 or lower indicate no common method bias [129]. Our results showed all VIFs were below this threshold, ranging from 1.000 to 2.671, confirming the absence of significant common method bias. Considering all these actions, it can be concluded that common method bias is unlikely to pose a significant threat to this study.

2) DESCRIPTIVE STATISTICS

The descriptive statistics are analysed to gain insights into the characteristics of the sample, as demonstrated in Table 2. Concerning gender, 92.2% of the participants are male, and 7.8% are female. The educational background reveals that 13.6% of the sample have A-level qualifications, 47.1% hold a bachelor's degree, 25.2% have a college degree, and 14.1% possess postgraduate degrees. In terms of relationship status, 60.2% are married, 38.3% are single, and 1% are divorced. Additionally, we examined the respondents' prior experience with Umrah; 51% have performed Umrah before, while 49% have not. Regarding the ethnic backgrounds of the respondents, 52.4% are Asian, 34.5% are Arab, 7.8% are Black, 0.5% are White, and the remaining 4.9% belong to other ethnic groups.

This section presents a descriptive analysis of the constructs utilised in this study, as detailed in Table 3. The table outlines the mean, standard deviation, skewness, and kurtosis for each variable, providing a comprehensive overview of the data distribution. The mean values for the constructs indicate that most variables were centred above the midpoint of the scale, reflecting generally positive responses from participants. Specifically, the mean scores for constructs such as PU, TA, PEoU, PENJ, ATS, and UI were all above 4.00, suggesting that participants generally had favourable attitudes towards using the VR system and related experiences. The mean of AGE was computed according to the age group categorised by the Likert scale. The relatively lower mean for CS at 3.03 suggests a more moderate experience of discomfort among participants.

The standard deviations for the constructs were all below 1.15, indicating a relatively narrow spread of responses around the mean. This narrow range suggests that the participants' responses were consistent across the constructs measured. For instance, the standard deviation for UI was the lowest at 0.454, suggesting that the participants' intention to use the system was particularly uniform.

In terms of skewness and kurtosis, the data shows values within acceptable ranges, suggesting that the distribution of responses does not deviate significantly from normality. According to the thresholds established by [130], skewness values between -3 and 3 and kurtosis values between -10 and 10 are generally considered acceptable for normal distribution. In this study, skewness values ranged from 0.488 to -1.196, and kurtosis values ranged from -.273 to 1.402, indicating no significant issues with the normality of the data distribution.

These descriptive statistics suggest that the data collected were normally distributed across the constructs, which is a favourable condition for subsequent statistical analyses. The results indicate a stable and reliable dataset, reinforcing the validity of the subsequent analysis of the relationships between the constructs.

3) PLS-SEM ANALYSIS

We employed PLS-SEM for analysing our data using the SmartPLS 4 software. Several factors made PLS-SEM particularly suitable for our research. First, PLS-SEM is highly effective for exploring and predicting research models where the goal is to explain variance [131], [132]. Our goal is to investigate new relationships between technological anxiety, cybersickness, enjoyment, perceived ease of use and use intention through using a 'soft-modelling' approach [133], [134]. Given its exploratory and theory-building capabilities, PLS-SEM is well-suited for our research. Additionally, our model is complex, involving numerous relationships between constructs, and PLS-SEM provides robust solutions for such models [135], [136]. Finally, PLS-SEM requires only minimal sample size requirements to achieve strong statistical power [131], [137], [138]. With a moderate sample size of 207, which meets the 'ten times' rule, PLS-SEM is an appropriate and reliable method for our analysis [139], [140], [141].

B. ASSESSMENT OF THE MEASUREMENT MODEL

We adhered to the latest PLS-SEM guidelines and assessed the reliability and validity of our measurement model,

TABLE 2. Demographic Characteristics (N = 206) with a predominantly male sample (92.2%).

Attributes	Category	Frequency	Percentage
Age	18-25	66	32%
	26-35	70	34%
	36-45	46	22.3%
	46-55	10	4.9%
	56-65	14	6.8%
Ethnic group	Arab	71	34.5%
	White British	1	0.5%
	Black or African American	16	7.8%
	Asian / Pacific Islander	108	52.4%
	Other	10	4.9%
Gender	Male	190	92.2
	Female	16	7.8%
Education	A-Level	28	13.6%
	College	52	25.2%
	Bachelor	97	47.1%
	Postgraduate	29	14.1%
Relationship	Single	79	38.3%
	Married or domestic partnership	124	60.2%
	Divorced/ Separated	2	1%
	Widowed	1	0.5%
Participated in Umrah rituals before	Yes	101	49%
	No	105	51%
Familiar with VR	No previous knowledge	50	24.3%
	Slightly Aware of it	87	42.2%
	Aware of it	56	27.2%
	Completely aware of it	13	6.3%

TABLE 3. Descriptive Analysis highlighting agreement levels and data variability.

	Mean	Std. Deviation	Skewness	Kurtosis
AGE	2.20	1.147	.892	.209
PU	4.52	.588	-1.164	.915
TA	4.18	.756	-.939	.961
PEoU	4.48	.561	-1.044	.879
PENJ	4.56	.503	-1.190	1.402
CS	3.03	.841	.488	-.273
ATS	4.52	.588	-1.164	.915
UI	4.65	.454	-1.196	.988

which included constructs with reflective indicators. In line with [142], we evaluated internal reliability using Cronbach's Alpha and composite reliability (CR). All Cronbach's Alpha scores were above 0.7, ranging from 0.739 to 0.889, and CR scores also exceeded 0.7, ranging from 0.860 to 0.931. These results indicate adequate reliability for the composite measurement items [135]. We also checked the reliability of each indicator using a minimum threshold of 0.5 for the outer loadings of indicators [143], [144]. The standardised first-order outer loadings ranged from 0.715 to 0.924, with all items surpassing 0.7, thus confirming the reliability of individual items.

To evaluate construct validity, we examined both convergent and discriminant validity. Convergent validity was assessed following [145], who recommend an average variance extracted (AVE) of at least 0.5. All constructs had AVE values above this threshold, ranging from 0.672 to 0.818, indicating satisfactory convergent validity. The reliability and validity of each construct are detailed in Table 4.

Discriminant validity was evaluated using the Fornell-Larcker criterion and the heterotrait-monotrait (HTMT) ratio. As shown in Table 5, the square roots of the AVE for each latent variable were higher than the highest squared correlations with any other latent variable, confirming discriminant

TABLE 4. **Measurement items, outer loadings, t-values, and reliability indicators, confirming internal consistency and validity.**

Construct	Construct Measure	Outer Loading	T-value	Reliability		Validity
				Composite Reliability	Cronbach's Alpha	AVE
Attitude Towards System (ATS)	ATS1	0.880	40.119	*0.900*	*0.838*	*0.751*
	ATS2	0.865	37.453			
	ATS3	0.855	31.601			
Cybersickness (CS)	CS1	0.889	14.844	*0.885*	*0.739*	*0.793*
	CS2	0.892	19.310			
Perceived Enjoyment (PENJ)	ENJ1	0.715	11.764	*0.873*	*0.783*	*0.698*
	ENJ2	0.902	52.806			
	ENJ3	0.878	36.710			
Perceived Ease of Use (PEoU)	PEoU1	0.887	49.624	*0.884*	*0.803*	*0.717*
	PEoU2	0.877	40.226			
	PEoU3	0.773	17.824			
Technology Anxiety (TA)	TA1	0.780	15.857	*0.860*	*0.756*	*0.672*
	TA2	0.844	22.443			
	TA3	0.834	30.460			
Use Intention (UI)	UI1	0.924	57.609	*0.931*	*0.889*	*0.818*
	UI2	0.887	23.424			
	UI3	0.901	42.436			

validity for the entire sample and for the subgroups based on socio-geographic context. Additionally, HTMT ratios, which offer a newer criterion developed by [146], were all below the conservative threshold of 0.900, further confirming discriminant validity [142], [146]. Table 6 presents the HTMT results.

To ensure the reliability and validity of our findings, we conducted a thorough assessment of statistical assumptions including normality, multicollinearity, and measurement validity. Normality tests indicated that skewness and kurtosis values for all constructs fell within acceptable ranges [147], confirming that the data distribution did not significantly deviate from normality. Multicollinearity was assessed using variance inflation factor (VIF) values, all of which were below the recommended threshold of 3.0 [148], indicating no collinearity concerns.

Measurement validity was confirmed through Average Variance Extracted (AVE) and Composite Reliability (CR). All AVE values exceeded 0.50, and CR values surpassed 0.70, demonstrating strong construct reliability. Furthermore, discriminant validity was verified using the Fornell-Larcker criterion and heterotrait-monotrait (HTMT) ratio, confirming that the constructs were distinct and conceptually sound.

Additionally, we acknowledge that potential confounding factors such as prior exposure to VR, educational background, and gender differences may have influenced responses. While our sensitivity analysis controlled for these factors, future research should incorporate stratified sampling and subgroup analysis to further investigate their impact on VR adoption and technology anxiety.

1) MODEL RESULTS AND HYPOTHESIS TESTING

After confirming our measurement model's reliability and validity, we evaluated the structural model. The model's predictive capability was assessed through the variance explained (R_2) of the endogenous constructs, as outlined by Chin, Henseler [149]. According to Chin [150], r_2 values of 0.67, 0.33, and 0.19 represent substantial, moderate, and weak predictive power, respectively. For our model, the r_2 values are 0.515 for intention to use and 0.578 for attitude towards the system, suggesting a moderate level of predictive power [150], [151].

To evaluate the impact of independent latent variables on dependent latent variables, we calculated the effect size f_2, which measures the change in r_2 [142], [149]. Effect sizes are categorised as small (0.02), medium (0.15), and large (0.35) [149], [152]. The effect sizes for technological anxiety on cybersickness, ease of use, and enjoyment are 0.060, 0.718, and 0.058, respectively. These results indicate small effects of technological anxiety on cybersickness and enjoyment and a large effect on ease of use. For the impact of cybersickness, ease of use, and enjoyment on attitude towards the system, the effect sizes are 0.002, 0.067, and 1.035. These results show small effects of cybersickness and ease of use on attitude towards the system and a large effect of enjoyment on attitude towards the system. Lastly, the effect size of attitude towards the system on use intention is 1.029, indicating a large effect.

To test our hypotheses and determine the significance of the path coefficients, we employed the bootstrapping technique [131], [142], using a resampling method of 5000 iterations with the 207 observations. The path coefficients from past use and age to technology anxiety are 0. 210 ($t = 2.404$, $p = 0.016$) and −0.321 ($t=4.271$, $p=0.000$) respectively, which indicate both h1 and h2 are supported. The path coefficients from technology anxiety to ease of use, enjoyment, and cybersickness are 0.647 ($t = 14.038$, $p = 0.000$), 0.233 ($t = 3.196$, $p = 0.001$) and −0.238 ($t = 3.259$, $p = 0.001$), confirming that h3, h4 and h5 are also supported. The path coefficients from ease of use, enjoyment and cybersickness to attitude towards systems are 0.179 ($t = 3.744$, $p = 0.000$), 0.689 ($t = 15.854$, $p = 0.000$) and −0.026 ($t = 0.634$, $p = 0.526$), which support h6 and h7 and reject

TABLE 5. Discriminant validity (Fornell-Lackereach construct's AVE square root exceeds its correlations with other constructs.

	AGE	ATS	CS	PEoU	PENJ	PU	TA	UI
AGE	1.000							
ATS	-0.018	0.867						
CS	0.417	-0.057	0.891					
PEoU	-0.341	0.376	-0.18	0.847				
PENJ	0.037	0.739	0.004	0.28	0.836			
PU	-0.324	-0.019	-0.15	0.273	-0.056	1.000		
TA	-0.389	0.304	-0.24	0.647	0.233	0.315	0.820	
UI	-0.097	0.712	-0.15	0.426	0.596	0.025	0.338	0.904

TABLE 6. Discriminant validity (HTMT results) confirming discriminant validity with values below 0.90, indicating distinct constructs.

	AGE	ATS	CS	PEoU	PENJ	PU	TA	UI
AGE								
ATS	0.033							
CS	0.486	0.085						
PEoU	0.377	0.464	0.237					
PENJ	0.077	0.900	0.130	0.350				
PU	0.324	0.060	0.170	0.298	0.079			
TA	0.440	0.396	0.312	0.810	0.307	0.355		
UI	0.105	0.816	0.184	0.502	0.709	0.028	0.419	

TABLE 7. Results of structural model testing supporting relationships among TA, PEoU, PENJ, and Cybersickness.

	Hypothesis	Path coefficients	T-statistics	P values	95% confidence intervals	Significant
H1	PU → TA	0.210	2.404	0.016	[0.032, 0.364]	Yes
H2	AGE → TA	-0.321	4.271	0.000	[-0.461, -0.167]	Yes
H3	TA → PEoU	0.647	14.038	0.000	[0.557, 0.738]	Yes
H4	TA → PENJ	0.233	3.196	0.001	[0.085, 0.369]	Yes
H5	TA → CS	-0.238	3.259	0.001	[-0.382, -0.097]	Yes
H6	PEoU → ATS	0.179	3.744	0.000	[0.087, 0.273]	Yes
H7	PENJ → ATS	0.689	15.854	0.000	[0.597, 0.768]	Yes
H8	CS → ATS	-0.026	0.634	0.526	[-0.105, 0.058]	No
H9	ATS → UI	0.712	15.800	0.000	[0.622, 0.797]	Yes

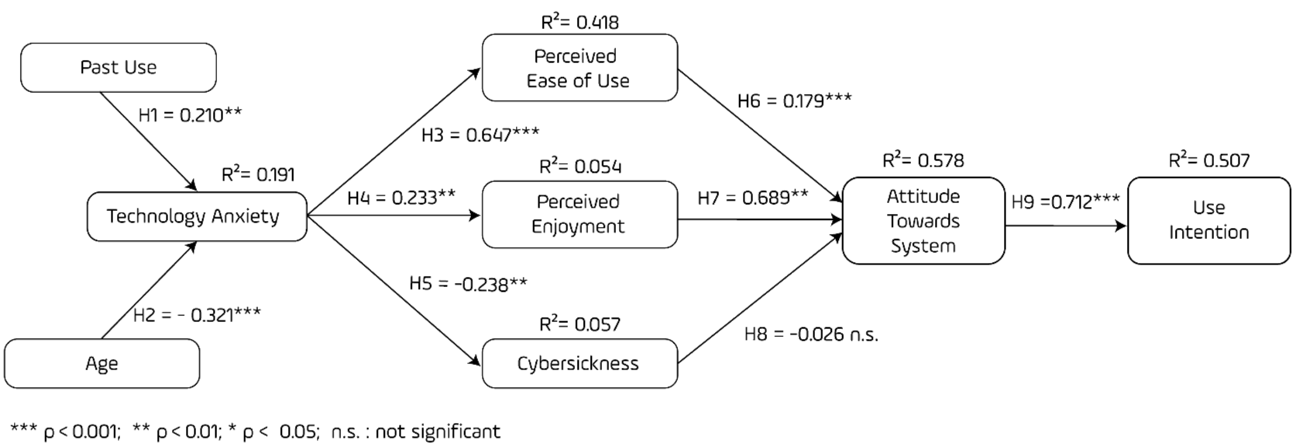

FIGURE 2. Assessment of the structural model.

h8. Finally, the part coefficient from attitude toward systems to use intention is 0.712 (t = 15.800, p = 0.000), which confirms h9. The results are presented in Table 7 and Figure 2 below.

The findings indicate that past use increases technology anxiety, whereas age has a negative impact on it. In turn, technology anxiety positively influences ease of use and enjoyment, and negatively affects cybersickness. While ease of use and enjoyment positively shape attitudes toward the system, cybersickness does not have a significant impact. Finally, a positive attitude toward the system strongly predicts use intention.

V. CONCLUSION AND DISCUSSION

This study examined how technology anxiety, influenced by age and past use, affects users' perceptions of VR technology, particularly in the context of a religious pilgrimage. The VR simulation, designed to replicate a profoundly significant religious ritual, provided a unique opportunity to examine how TA interacts with PEoU, PENJ, and cybersickness in an emotionally intense environment. By integrating age and past use as primary antecedents of TA, this study provides novel insights into technology adoption within immersive cultural and religious settings.

This study showed an influence on technology anxiety caused by past use, as individuals who had prior experience with VR or similar immersive technologies showed higher anxiety levels ($\beta = 0.210$, $p < 0.05$). This finding challenges conventional assumptions that familiarity with a system reduces TA. Instead, it suggests that past exposure to VR may heighten awareness of its challenges, such as motion sickness, technical difficulties, or usability barriers, leading to increased anxiety when engaging with the technology again. This does not align with research indicating that past use experience with technology has been found to reduce anxiety levels and increase acceptance of digital health technologies [153]. A possible explanation for this discrepancy is that VR, unlike other digital technologies, presents a uniquely immersive and physically engaging environment where prior negative experiences (e.g., cybersickness, disorientation, or control complexities) may be more salient and memorable. The increased anxiety among experienced users highlights the need for better-designed VR interfaces, improved user guidance, and adaptive support systems to prevent past negative experiences from deterring continued adoption.

Conversely, one of the central novel findings of this study was the significant role of age group in shaping TA. Our results indicate that older users reported significantly lower levels of technology anxiety compared to younger users ($\beta = -0.321$, $p < 0.01$), challenging the widely held assumption that age correlates with higher technology-related stress. Unlike younger participants, older individuals in our study exhibited greater ease when engaging with VR technology, suggesting that age alone is not necessarily a predictor of increased anxiety. Instead, factors such as prior exposure, learning adaptability, and expectations may play a more significant role in shaping technology anxiety. These findings stand in contrast to previous research, which suggests that older adults tend to experience higher technology anxiety due to stereotype threat and digital exclusion. Researchers argue that stereotype threat reinforces negative self-perceptions among older individuals, making them more reluctant to engage with new technologies [80]. Similarly, scholars emphasise that limited digital engagement among older users contributes to heightened anxiety, as digital ageism and lack of familiarity create psychological barriers to adoption [154]. Based on these perspectives, one would expect older adults to exhibit higher anxiety levels, yet our results indicate the opposite. A possible explanation for this discrepancy is that older users may approach VR technology with a more pragmatic and patient mindset, leading to lower stress levels during interaction. Unlike younger users, who may have higher expectations for seamless usability and immediate proficiency, older users may be less prone to frustration and more willing to tolerate a learning curve. These findings suggest that technology anxiety is not solely a function of age but is shaped by individual experiences, expectations, and adaptability.

The study found a positive relationship between TA and PEoU ($\beta = 0.647$, $p < 0.001$), suggesting that individuals who experience higher anxiety toward technology may paradoxically perceive the system as easier to use over time. While this finding may initially appear counterintuitive—given that anxiety is typically expected to hinder perceived ease of use—it aligns with studies that indicate that anxiety can act as a motivational force, driving individuals to engage more actively with technology to overcome their fears [155]. This phenomenon has been observed in digital learning environments [107] and in older adults using wearable healthcare technologies [93], where anxious users tend to develop higher engagement with a system to compensate for their initial discomfort. One potential explanation is that users experiencing TA may dedicate more cognitive effort to learning how to use the system efficiently, leading to a higher perception of ease of use after repeated exposure. This aligns with research suggesting that a learning curve effect may exist, wherein individuals initially experiencing stress or hesitation toward a system later report greater ease in using it as they gain familiarity and self-efficacy [156]. Another possible interpretation is that TA's effect on PEoU may vary depending on context. In this study, the immersive nature of the VR experience may have allowed even anxious users to quickly adapt, making the system appear easier to use than expected. This would contrast with more traditional digital interfaces, where technology anxiety has been shown to be a barrier to perceived usability.

The study found a positive relationship between TA and PENJ ($\beta = 0.233$, $p = 0.001$), suggesting that users who experienced higher levels of TA did not necessarily find the experience less enjoyable; rather, their anxiety might have intensified their engagement with the immersive VR setting. This contrasts with conventional expectations that higher TA would lead to lower enjoyment due to increased cognitive load and usability concerns. Instead, the results indicate that in immersive contexts such as VR, anxiety may not always act as a deterrent but could, in some cases, enhance user engagement and emotional involvement. This finding does not fully align with prior assumptions that TA is a limiting factor in user experience, as some studies suggest that anxiety leads to disengagement and lower satisfaction. However, scholars provide an alternative perspective, suggesting that technology anxiety does not always suppress user engagement but can, in some cases, heighten emotional responses in immersive experiences [81]. This could explain why, despite experiencing anxiety, users in this study may have found the VR pilgrimage experience more engaging, possibly due to the emotionally significant nature of the simulation.

A key novel contribution of this study was its exploration of TA and cybersickness. The study found a negative relationship between TA and CS (β = -0.238, p = 0.001), suggesting that higher anxiety was associated with lower cybersickness symptoms. This challenges the common assumption that TA exacerbates cybersickness by increasing cognitive strain and physiological discomfort. However, this finding does not fully align with previous research, such as [98], which suggested that anxiety contributes to symptoms of nausea and disorientation in immersive environments. Their work indicates that TA is often linked to heightened physical discomfort, particularly in visually and sensorily complex VR settings, which contrasts with the negative relationship observed in this study. The possible explanation for this unexpected result is that users with higher TA may have interacted more cautiously with the VR environment, minimising sudden movements and limiting their exposure to sensory mismatches that trigger cybersickness. In contrast, those with lower anxiety may have explored the environment more freely, leading to greater instances of cybersickness due to increased sensory conflicts. However, unlike previous studies that suggested a strong link between cybersickness and negative attitudes towards the system [157], this study found that cybersickness did not significantly affect participants' overall attitude towards the system (β = -0.02, p = 0.52). This difference may be explained by the unique context of the religious pilgrimage, where the emotional and spiritual significance of the ritual outweighed the physical discomfort caused by cybersickness. Participants appeared to be willing to endure discomfort to complete the religious experience, indicating that in specific contexts, the emotional or cultural value of the experience can override physical drawbacks.

Moreover, PENJ exhibits the strongest influence (β = 0.689, $p < 0.001$), suggesting that users who perceived the system as enjoyable, even in the presence of anxiety, were more inclined to develop a positive attitude toward it. Consequently, negative attitudes towards the system were not solely driven by TA but were largely dependent on users' perceptions of ease of use and enjoyment. Since Attitude Towards the System significantly predicted Use Intention (β = 0.712, $p < 0.001$), these findings emphasize the need to enhance both usability and engagement aspects of VR systems to maximize adoption in religious and cultural experiences.

This result is particularly significant when considering the role of VR in cultural and religious contexts, where technology is not merely an entertainment tool but a means of engaging with deeply personal and meaningful experiences. The immersive nature of VR pilgrimage experiences, coupled with the emotional and spiritual significance of participation, likely intensifies the impact of TA. Users who experience technical difficulties may feel an additional burden, as they are not just learning a new system but attempting to observe a sacred event in an unfamiliar digital environment. This highlights the need for tailored interventions to reduce anxiety and improve user comfort, particularly for older individuals and those with limited previous exposure to VR technologies.

Our findings highlight that PEoU and PENJ are key drivers of VR acceptance. Researchers reinforce this by demonstrating that well-designed VR and AR interfaces enhance engagement, simplify interactions, and reduce adoption barriers in healthcare settings [158]. This alignment suggests that intuitive design is crucial across contexts, including tourism and religious applications, to improve user attitudes and promote adoption.

Considering the diverse needs of users, especially those with limited mobility, is essential in VR design. Scholars propose a design space that maps unimanual input to bimanual interactions, enhancing accessibility and potentially increasing user acceptance of VR technologies [159].

While Technology Anxiety plays a significant role in individual VR adoption, recent research suggests that social aspects, such as collaborative experiences in virtual workplaces, may also shape user perceptions and adoption rates. Collaborative VR environments foster social interaction, which can reduce anxiety and enhance perceived usefulness and enjoyment, thereby increasing overall adoption [160].

VI. CONTRIBUTIONS AND IMPLICATIONS

This study makes several significant contributions to the literature on Technology Anxiety and technology adoption in immersive environments. First, it extends the TAM by incorporating age, past use, and cybersickness as key factors influencing user intention in VR, particularly in emotionally and culturally significant contexts. Second, it highlights the complex role that TA plays in shaping both cognitive and emotional responses to VR, showing that anxiety can detract from ease of use and enjoyment while simultaneously heightening emotional engagement in some cases.

The use of VR for a religious pilgrimage also introduces a new dimension to the study of technology adoption, demonstrating how cultural and spiritual factors can moderate the effects of Technology Anxiety. In addition to its theoretical contributions, this study highlights key practical implications for VR adoption and user engagement. Addressing technology anxiety requires a holistic approach involving user-centered design, adaptive interfaces, policy initiatives, and community engagement. The following recommendations provide actionable strategies for improving VR accessibility and reducing barriers to adoption. To reduce technology anxiety in VR adoption, developers and policymakers need to focus on gradual onboarding, adaptive systems, and accessibility features. Phased onboarding can help new and older users ease into VR with step-by-step tutorials, starting with basic interactions before introducing advanced features. This gradual exposure reduces the initial anxiety spike and improves user confidence.

Adaptive VR systems that adjust in real-time based on user feedback, such as head movements or physiological signals, can help minimise discomfort. Slowing down movement, simplifying interactions, or stabilising visuals can make VR more comfortable, particularly for those prone to cybersickness. Additionally, assistive interface features like larger text, reduced motion settings, and audio guidance can enhance usability, especially for older adults or users unfamiliar with digital technology.

Policy support can further encourage inclusive VR adoption. Funding incentives for accessible design and industry-wide guidelines for reducing cybersickness can push developers to create more user-friendly experiences. Additionally, community outreach programs, such as "try-before-you-buy" events in libraries or community centres, can introduce VR in social settings where peer support reduces anxiety and builds confidence.

A multifaceted approach combining thoughtful design, real-time adaptation, policy incentives, and community engagement is essential to overcoming technology anxiety. These strategies will make VR more accessible, inclusive, and widely adopted, particularly for older users and first-time adopters.

VII. LIMITATIONS AND FUTURE STUDIES

This research encompasses some limitations. First, the study sample is dominated by male participants, which may introduce gender-related biases. Researchers noted that men tend to experience higher levels of immersion presence in virtual environments compared to women [161]. Additionally, prior studies suggest that women may experience higher levels of technology anxiety than men [93], which could impact how they interact with VR. The underrepresentation of women in this study limits the ability to generalise findings across genders. Future research should incorporate a more gender-balanced sample to explore potential differences in VR adoption and technology anxiety. Second, the age distribution of participants is skewed towards younger individuals (18-45 years), limiting the study's applicability to older adults. Research suggests that Gen Z and millennials are more tech-savvy than older users, which may influence their experience with VR technology. Studies highlighted that older generations (e.g., Gen X) tend to experience lower immersion in VR environments compared with younger users [162]. Since the majority of participants were in the younger age groups, findings may not fully reflect the challenges and perceptions of older individuals, who are more likely to experience technology anxiety. Third, the study sample was drawn from a specific religious and cultural context, which may limit generalisability, while religious significance of the pilgrimage experience provided valuable insights, cultural attitudes towards technology adoption vary across different populations. Future studies could consider cross-cultural comparisons to measure how different religious and cultural backgrounds influence VR adoption and technology anxiety. While results provide valuable insights for the tourism industry, further research involving diverse populations and contexts is necessary to reinforce the validity of these results and broaden their relevance to other sectors, such as education, healthcare, and hospitality.

This study's generalizability is limited due to the overrepresentation of young (66% aged 18–35) and male participants (92.2%), potentially skewing findings on technology anxiety and VR adoption. Research indicates that age and gender influence technology anxiety and immersive experience engagement. Future studies should employ stratified or quota sampling to ensure a balanced demographic representation. A longitudinal approach could further capture how VR adoption evolves across user groups. Expanding diversity would improve external validity, enabling deeper insights into how different populations engage with VR and experience technology anxiety in various contexts.

Future research should adopt a longitudinal approach to examine how prolonged exposure to VR affects technological anxiety, particularly among older and novice users. This would help identify adaptation phases, understand the temporal dynamics of anxiety reduction, and provide targeted interventions to enhance ease of use, enjoyment, and long-term user engagement with immersive technologies. While this study provides valuable insights into the relationship between technological anxiety and VR adoption, future research should also explore how innovative VR interfaces can enhance ease of use and usability. Recent advancements in digital healthcare have demonstrated the potential of VR/AR to create intuitive interfaces that improve user interaction, particularly in training and patient engagement contexts [158]. Another part of the future research will explore adaptive and customisable VR interfaces to enhance accessibility by following some studies that introduced a modular 3D interface that allows users to personalise their interaction experience [163], [164].

Furthermore, Prior VR experience, education level, and gender differences may have influenced findings. Participants with VR exposure likely reported lower anxiety and higher usability perceptions. Similarly, higher education levels may correlate with greater adaptability to technology, reducing anxiety. Gender differences in VR engagement and anxiety responses remain underexplored due to the male-dominated sample. Future research should include balanced samples and subgroup analyses to examine these variables' impact on VR adoption. Addressing these confounding factors will improve result accuracy, ensuring broader applicability and deeper insights into how diverse populations engage with VR technologies.

While this study provides valuable insights into the relationship between technology anxiety and user experience in VR, certain limitations highlight areas for further exploration. In future research, it would be valuable to explore how different types of cultural or religious VR experiences impact TA and how emotional significance interacts with cybersickness

TABLE 8. Questionnaire used in the study with sources.

Constructs	Questionnaire items	Sources
Technology Anxiety (TA)	TA1: I am totally comfortable working with virtual reality applications. TA2: I don't feel anxious while using the VR headset TA3: I don't seek social support while using VR headset	[165, 166]
Perceived Ease of Use (PEoU)	PEoU1: Using the VR Omrah application is easy; it depends on using VR devices PEoU2: Learning to operate the VR Umrah app would be easy for me PEoU3: My interaction with the VR Umrah app was clear and understandable.	[167-169]
Perceived Enjoyment (PENJ)	PENJ1: Time passed quickly when using the VR application PENJ2: The VR Omrah experience is exciting. PENJ3: I enjoyed using the VR Omrah application.	[106, 168, 170]
Cybersickness (CS)	CS1: Do you experience nausea (e.g stomach pain, acid reflux, or tension to vomit CS2: Do you experience postural instability (i.e., imbalance). CS3: Mobility makes it possible to get the required information on time	[171]
Attitude Towards System (ATS)	ATS1: Using the VR Umrah application is a good idea ATS2: Visiting Masjid Al Haram makes me feel good ATS3: I'd recommend the experience to my friends	[170]
Use Intention (UI)	UI1: I intend to use the VR Omrah application in the future UI2: In the future, I intend to use the VR Umrah application to practice Umrah rituals UI3: I will strongly recommend the use of Virtual reality Umrah app to my peers who want to learn Umrah rituals.	[172]

Note(s): *CS3 was deleted because of low factor loading (<0.7)

and other physical discomforts in VR. Additionally, further studies could investigate longitudinal changes in TA, particularly as users gain more experience with VR, to better understand how anxiety evolves over time and with repeated use.

DECLARATION

Informed consent was received from all participants. Consent for publication has also been received from all relevant parties. Supporting data and materials are available upon request. The authors declare no potential conflicts of interest concerning this article's research, authorship, and publication. No funding for this project. Eman Al Khalifah contribution included conceptualisation, writing, methodology, data collection and analysis. Ramy Hammady and Mahmoud Abdelrahman contributions included data collection, conducting analysis, writing results, review and editing. Ons Al-Shamaileh, Mostafa Marghany, and Hatana El-Jarn contributions included writing, funding acquisition, supervision, and review. Alyaa Darwish and Yusuf Kurt contributions included data analysis, and reviews. They would like to acknowledge the reviewers and editorial team for their constructive suggestions and invaluable feedback on their article.

APPENDIX

In Table 8 below, the questionnaire is listed with related sources, considering the context of the technology.

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