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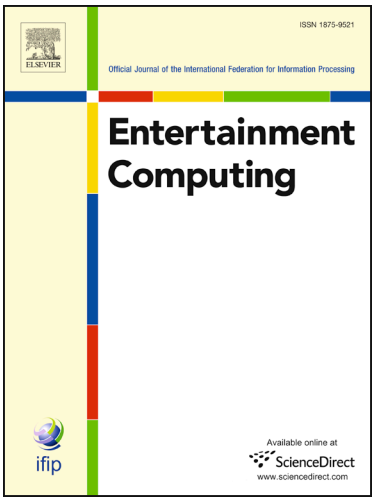

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When a Virtual Museum is Too Good: The Curiosity Satisfaction Paradox and its Implications for the Substitution Effect of Virtual Technology

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Highlights

- VR-gamified app is more usable than a museum website.
- VR platforms boost pre-visit intentions and sharing.
- Gamification does not significantly enhance VR experience.
- Introduces the "curiosity satisfaction paradox."
- Highly comprehensive VR may substitute for physical visits.

Abstract

This mixed-methods study evaluates the strategic efficacy of digital museum platforms by comparing a traditional museum website with a VR-only app and a VR-gamified app. Ninety participants were randomly assigned to one platform, after which they completed the System Usability Scale (SUS) and Museum Experience Scale (MES); semi-structured interviews provided crucial qualitative depth. Our quantitative findings reveal a significant difference in usability, with the VR-gamified app outperforming the website ($\chi^2(2)=9.778$, $p=.001676$), indicating a medium effect size ($\epsilon^2=.110$). However, the VR-only app was not significantly different from the website ($p = 0.09174$). Additionally, gamification did not significantly enhance the museum experience over the VR-only app, suggesting a potential ceiling effect of VR

immersion. Critically, qualitative insights revealed a novel "curiosity satisfaction paradox": while both VR apps significantly influenced participants' pre-visit intentions and willingness to share, demonstrating a compelling "teaser" effect, the comprehensive VR-gamified experience surprisingly satisfied the curiosity of some users, reducing their motivation for a physical visit. This study underscores the need for a nuanced strategic approach to ensure digital platforms effectively complement, rather than inadvertently substitute for, the physical museum experience

Keywords: Virtual Reality, User Experience (UX), Curiosity Satisfaction Paradox, Gamification, Museum

1.0 Introduction

In a world increasingly driven by digital experience, museums must expand beyond traditional, passive engagement to remain relevant (Li et al., 2024). The International Council of Museums (ICOM) defines a museum's functions as researching, collecting, conserving, interpreting, and exhibiting heritage for societal benefit (ICOM, 2022). However, many institutions worldwide face challenges in keeping visitors engaged and attracting younger demographics (Kluge-Pinsker & Stauffer, 2021). This challenge is acutely felt in Malaysia, where museums, including prominent institutions like the National Museum of Malaysia and the Chinese History Museum, Sarawak, face persistent issues such as limited digital adoption and reliance on static exhibition methods (Fauzi et al., 2022; Rahman & Velayuthan, 2024). This often results in low visitor numbers and ineffective marketing (Malaysian Now, 2022).

To stay relevant and expand their reach, museums are increasingly adopting digital technology to enhance visitor experiences (Li et al., 2024; Tham et al., 2025). The COVID-19 pandemic significantly accelerated this digital shift (Nikolaou, 2024), prompting institutions like the British Museum to rapidly implement virtual reality (VR) for online tours and improved accessibility (British Museum, 2025). The widespread use of smartphones and VR devices further promotes VR's transformative potential in tourism and cultural sectors. By delivering immersive, interactive, and personalised experiences that surpass physical space limitations (Massari et al., 2024; Zhao et al., 2025), VR can recreate historical environments, enhance interpretations, and boost engagement. Although virtual experiences can positively influence intentions for an in-person visit (Deng et al., 2025; Sun et al., 2025; Li YiFei & Othman, 2024), a key challenge is designing content that maintains interest beyond initial novelty without inadvertently substituting for the physical experience.

Complementing VR, gamification, defined as the application of game-design elements and principles in non-game contexts to enhance user engagement (Houtari & Hamari, 2017) and value creation (Paschmann et al., 2025), ffers a powerful strategy for revitalising museum experiences. It transforms passive viewing into active participation (Nofal et al., 2024; Ivanov & Velkova, 2025) and has proven effective in boosting motivation and knowledge retention in heritage settings, such as the Royal Museum of Art and History in Brussels (Nofal et al., 2020) and in mobile tourism applications (Chauhan & Karthikeyan, 2025; Sanfilippo et al., 2025).

1.1 Problem Statement and Research Gaps

While both VR and gamification have shown promise in enhancing museum engagement, their combined use offers an under-researched path for sustained, deeper interaction, especially in terms of converting virtual engagement into real-world visits. Incorporating game mechanics into immersive VR environments can transform passive virtual tours into active, goal-oriented learning experiences (Agustini et al., 2023; Kotsifakos et al., 2022; Tongpaeng et al., 2024). However, comprehensive empirical evidence on how this synergy affects pre-visit engagement remains critically limited, particularly in under-digitised museum environments common in Malaysia (Sangamuang et al., 2025; Tongpaeng et al., 2024; Lei et al., 2025).

Furthermore, an emergent theoretical concern, the 'curiosity satisfaction paradox', lacks clear empirical quantification within this context. This paradox posits that a highly immersive and comprehensive virtual experience might unintentionally diminish the desire for a physical visit by fully satisfying a user's curiosity virtually (Anwar et al., 2025; Jiang et al., 2025; Pantelidis et al., 2024; Sharma et al., 2025; Yersüren & Özel, 2024; Zeqiri, 2024). While some studies suggest virtual tours foster physical visits (Chekembayeva & Garaus, 2024), others hint at substitution effects (Sharma et al., 2025). This research seeks to empirically investigate this nuanced outcome, offering a critical perspective on how digital content design can either stimulate or inadvertently displace real-world engagement. This study directly addresses these gaps by comparatively examining a VR-gamified application's efficacy against VR-only and traditional website interfaces in optimising user engagement and navigating this paradox within Malaysia’s unique museum landscape

1.2 Significance of the Study

This study offers important theoretical and practical contributions. Theoretically, it provides empirical evidence on how VR-gamified applications compare to VR-only and traditional website interfaces in terms of usability and experience. It pioneers the exploration of the ‘curiosity satisfaction paradox’, where immersive virtual tours may unintentionally satisfy curiosity and reduce the intent for a physical visit, enriching the Theory of Planned Behaviour by considering a novel behavioural control factor.

Practically, it offers a blueprint for Malaysian museums and other under-digitised regions to harness VR gamification as a dynamic marketing and educational tool. These insights can empower museum directors, digital developers, and policymakers to boost visitor numbers, address low digital adoption, and drive strategic digital transformation with engaging, user-centred designs. The Chinese History Museum case study offers a practical blueprint for other regional museums. Findings will assist museum directors in strategic planning, digital heritage developers in enhancing user experience (UX), and cultural policymakers in shaping digital transformation initiatives.

1.3 Research Questions

This mixed-methods study, employing user testing and qualitative interviews, seeks to answer the following research questions:

RQ1: What are the user-perceived strengths and weaknesses of the VR-gamified museum application's design elements in stimulating pre-visit engagement?

RQ2: How do a VR-gamified museum application, a VR-only application, and a traditional museum website compare in terms of perceived usability and the comprehensive user experience (e.g., engagement, knowledge acquisition, emotional connection)?

RQ3: How do participants' perceived usability and museum experience qualitatively influence their stated pre-visit intentions for the physical museum after interacting with these digital platforms?

RQ4: How do participants' perceived usability and museum experience qualitatively influence their stated propensity to share these digital platforms with others?

RQ5: What are the characteristics and emergence of the "curiosity satisfaction paradox" in a VR-gamified museum application, specifically examining how high immersion levels might diminish stated pre-visit intentions for a subset of users, and how can this be measured?

The following section outlines the literature review and theoretical framework. The subsequent section discussed research methodology, followed by results. Then we discussed the findings and concluded.

2.0 Literature Review and Theoretical Framework

This section reviews the evolution of museum engagement, examines the distinct and synergistic roles of virtual reality (VR) and gamification, and elucidates their impact on user experience (UX) and pre-visit intentions. The discussion specifically focuses on the context of Malaysia's under-digitised museums. Drawing on established theories, this section then develops a robust conceptual framework to investigate the emergent 'curiosity satisfaction paradox' and its nuanced influence on physical museum visits, directly addressing the challenges outlined in the introduction.

2.1. The Evolving Landscape of Museum Engagement

Historically, museums have functioned as static repositories, focusing on collection and preservation. However, they are now dynamic institutions that fulfil diverse societal roles, including education, social interaction, and cultural discourse (Falk & Dierking, 2000; Kluge-Pinsker & Stauffer, 2021). This necessitates a shift from passive viewing to active, engaging experiences to attract and retain audiences, particularly among younger demographics (Wang, 2024). The COVID-19 pandemic further accelerated this digital transformation (Nikolaou, 2024). This evolution presents both challenges in balancing traditional roles and compelling opportunities for deeper engagement, particularly in resource-constrained settings such as Malaysia.

2.2. Virtual Reality (VR) in Museum Contexts

Virtual Reality (VR) fundamentally transforms museum experiences by creating immersive environments that simulate historical settings or enable interaction with

inaccessible artefacts (Zhao et al., 2025). This technology significantly enhances user engagement and accessibility, transcending geographical barriers (Massari et al., 2024; Kruczek et al., 2024). Leading institutions like the British Museum have leveraged VR for online tours and improved accessibility (British Museum, 2025), aligning with museums' commitment to inclusivity (ICOM, 2022). Studies show VR fosters presence, boosting emotional connections, learning, and knowledge acquisition (Massari et al., 2024; Ribeiro et al., 2024; Sangamuang et al., 2025). Furthermore, it serves as a potent pre-visit marketing tool, stimulating curiosity and encouraging physical visits (Sun et al., 2025; Deng et al., 2025).

However, VR integration faces challenges including high costs, technical complexities, VR sickness, and cognitive overload (Li et al., 2024). Critically, VR's high immersion can paradoxically lead to passive use, failing to sustain active engagement beyond initial novelty. This risk is amplified by the 'curiosity satisfaction paradox' (see detailed discussion in Section 2.5.4), where highly immersive virtual content may fully satisfy curiosity and reduce the motivation for physical visitation. These limitations highlight the critical need for interactive elements, such as gamification, to sustain user interest.

2.3. Gamification for Cultural Heritage and Museum Engagement

Gamification, defined as applying game-design elements in non-game contexts to boost user motivation and engagement (Houtari & Hamari, 2017; Paschmann et al., 2025), is a powerful strategy across diverse fields. Its effectiveness stems from leveraging psychological principles that encourage deeper involvement, often inducing an optimal state aligned with Flow Theory (Csikszentmihalyi, 1990). Elements like points, badges, and leaderboards provide immediate feedback and foster accomplishment (Marinho et al., 2025), while quests and narratives transform passive observation into goal-oriented, interactive experiences (Hamari et al., 2014; Zhang & Huang, 2025). Narratives embed content in compelling storylines, deepening emotional connection and knowledge retention (Abusharieh et al., 2025; Chernbumroong et al., 2024).

In museums, gamification is transformative. It shifts visitors to active participation, enhancing engagement and fostering deeper exhibit connections (Nofal et al., 2020; Ivanov & Velkova, 2025). Practical applications include mobile apps for heritage sites with quizzes, GPS-triggered missions, and augmented reality (AR) overlays (Tongpaeng et al., 2024; Chauhan & Karthikeyan, 2025; Martinez et al., 2020; Sanfilippo et al., 2025). Examples such as the Royal Museum of Art and History in Brussels (Nofal et al., 2020) and the Louvre Museum's gamified audio guide (Nintendo, 2013) demonstrate its capacity to boost motivation and enhance knowledge retention. However, poorly designed mechanics risk superficial engagement, hindering deeper learning (Hamari et al., 2014). In Malaysia, where traditional exhibits often limit interaction, gamification offers a vital opportunity to make cultural learning interactive and compelling.

2.4. The Synergistic Potential of VR and Gamification

Integrating VR with gamification creates a powerful synergy for cultural institutions. VR provides deep immersion, while gamification offers dynamic interaction, motivation, and goal-setting, actively sustaining engagement and fostering learning. Research indicates this combination significantly improves learning outcomes, problem-solving skills, and user satisfaction in educational and cultural contexts (Kotsifakos et al., 2022; Agustini et al., 2023). For instance, gamified quizzes in VR tours enhance object recognition and boost user motivation. While some studies show VR-gamified approaches outperform traditional AR methods (Jeon et al., 2022), practical examples (e.g., Louvre's Nintendo 3DS guide) often remain non-immersive or less complex than the fully integrated, immersive VR experiences examined here, limiting their generalisability.

This study addresses these gaps by testing a bespoke, immersive, VR-gamified application at the Chinese History Museum in Sarawak, while examining the role of the curiosity-satisfaction paradox (detailed in Section 2.5.4) in moderating pre-visit outcomes.

2.5. Theoretical Framework

This study utilises established theories in human-computer interaction, UX, and consumer behaviour to develop a solid theoretical framework for understanding the effects of VR and gamification on museum engagement and visit intention.

2.5.1. Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT)

TAM posits that perceived usefulness (PU) and perceived ease of use (PEOU) shape user attitudes and adoption of technology (Davis, 1989). UTAUT extends TAM by incorporating social influence and facilitating conditions (Venkatesh et al., 2003). In this study, PEOU is operationalised through the System Usability Scale (SUS), measuring user perceptions of VR-gamified apps, with high usability being crucial for adoption.

2.5.2. Experiential Marketing and Consumption Theory

Building on Pine and Gilmore's Experience Economy (Pine & Gilmore, 2013), this framework suggests consumers seek memorable experiences, which museums provide through curated cultural encounters. Experiential Consumption Theory posits that compelling experiences increase engagement, learning, and emotional connections. This aligns with the Museum Experience Scale (MES) dimensions (Engagement, Knowledge/Learning, Meaningful Experiences, Emotional Connection) (Othman et al., 2011), which VR and gamification are hypothesised to amplify.

2.5.3. Flow Theory

Flow Theory describes a mental state of deep focus and enjoyment when skills match challenges (Csikszentmihalyi, 1990). In a well-designed gamified VR experience, challenges can induce a state of flow, thereby boosting engagement, learning, enjoyment, and a sense of achievement. This underpins increased engagement in gamified experiences and is critical for sustaining user interest beyond initial novelty, thereby addressing the paradox's risk of over-satisfaction.

2.5.4. Theory of Planned Behaviour (TPB) and the Curiosity Satisfaction Paradox

This study is primarily grounded in the Theory of Planned Behaviour (TPB) (Ajzen, 1991), which posits that an individual's intention to perform a behaviour (e.g., visiting a physical museum) is influenced by their attitude, subjective norms, and perceived behavioural control. Within this framework, a positive attitude toward the VR-gamified museum application, informed by its perceived usability (TAM) and experiential quality (Flow Theory, Experiential Marketing principles), is hypothesised to increase visitors' intentions to physically visit the museum.

However, this study introduces the 'curiosity satisfaction paradox' as a critical, novel factor that extends the TPB. This phenomenon suggests that a highly immersive virtual encounter might inadvertently diminish the perceived need for a subsequent physical visit by fully satisfying curiosity virtually (Yersüren & Özel, 2024). This aligns with emerging discussions on substitution or displacement effects of virtual experiences (Pantelidis et al., 2024; Jiang et al., 2025; Zeqiri, 2024; Anwar et al., 2025). The paradox suggests that virtual richness can reshape a user's attitude or perceived behavioural control, directly affecting the necessity of real-world engagement. This offers a nuanced perspective, contrasting with some findings that show virtual tours positively mediate physical visit intentions (Chekembayeva & Garaus, 2024), while aligning with others that indicate substitution (Sharma et al., 2025). Understanding this interplay is crucial for optimising digital content design in Malaysia’s context.

2.5.5. Conceptual Framework and Hypotheses

Figure 1 illustrates the relationships between digital museum platforms, user perceptions and experiences (perceived usability measured by SUS, based on TAM/UTAUT; museum experience measured by MES dimensions, based on Experiential Marketing and Flow Theory), and behavioural intentions (pre-visit intention and sharing propensity, based on TPB, measured qualitatively). The curiosity satisfaction paradox moderates the effect of the digital experiences on pre-visit intention, potentially reducing intentions when virtual experiences fully satisfy curiosity. Dashed lines in the framework indicate qualitative relationships, while solid lines represent relationships tested quantitatively.

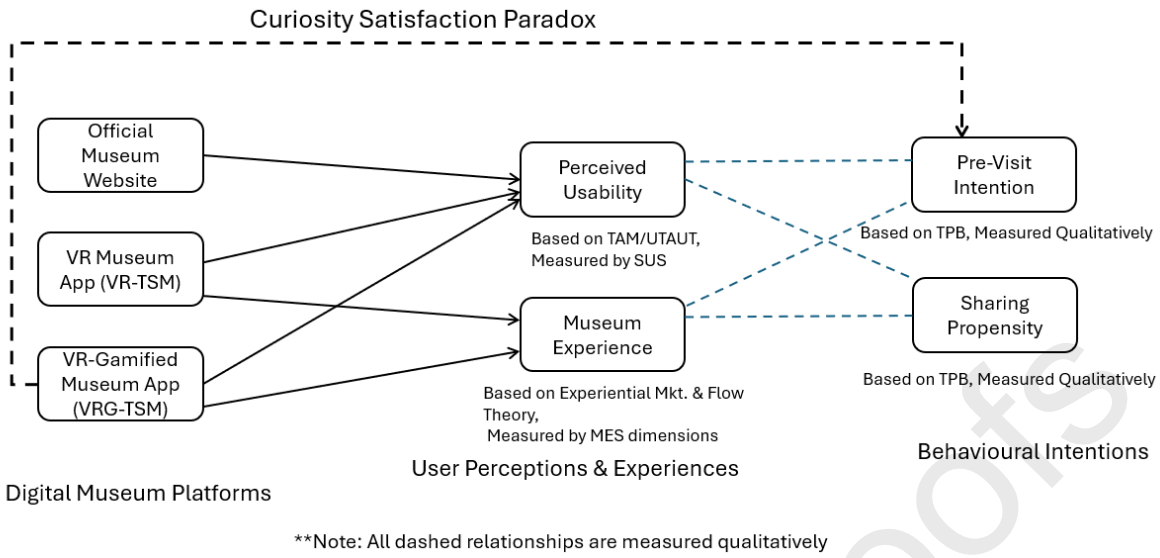

Figure 1. Conceptual Framework of the Study

Based on this conceptual framework, the study addresses its overall research questions through a set of specific testable hypotheses (for quantitative inquiries) and research questions:

Quantitative Research Questions (RQ2) and Hypotheses:

- RQ2: How do a VR-gamified museum application, a VR-only application, and a traditional museum website compare in terms of perceived usability and the comprehensive museum experience?
- H1: The VR Museum App will exhibit significantly higher perceived usability than the Official Museum Website.
- H2: The VR-Gamified Museum App will exhibit significantly higher perceived usability than the Official Museum Website.
- H3: The VR-Gamified Museum App will significantly enhance the museum experience (specifically across the dimensions of Engagement, Knowledge/Learning, and Emotional Connection) compared to the VR Museum App.

Qualitative Research Questions (RQ1, RQ3, RQ4, RQ5):

- RQ1: How do specific design elements (e.g., interactivity, narrative, rewards) within a VR-gamified museum application influence user-perceived engagement and overall user experience?
- RQ3: How do participants' perceived usability and museum experience qualitatively shape their stated pre-visit intentions for the physical museum after interacting with these digital platforms?

- RQ4: How do participants' perceived usability and museum experience qualitatively influence their stated propensity to share these digital platforms with others?

- RQ5: What are the characteristics and emergence of the "curiosity satisfaction paradox" in a VR-gamified museum application, where a comprehensive virtual experience may diminish the stated pre-visit intention for a subset of users?

3.0 Methodology

This section outlines the methodology for assessing the impact of digital museum platforms on user experience (UX), pre-visit intention, and sharing propensity within Malaysia's museum context. It details the mixed-methods design, application development, experimental procedure, data analysis, and ethical considerations, aligning directly with the research questions and conceptual framework.

3.1 Research Design and Application Development

3.1.1 Research Design

A sequential explanatory mixed-methods design was adopted, combining quantitative and qualitative phases. The quantitative phase employed a true experimental, between-subjects design to compare the Official Museum Website, the VR Museum App (VR-TSM), and the VR-Gamified Museum App (VRG-TSM) on perceived usability and museum experience (Figure 1). Participants (N=90) were randomly assigned to one of these three conditions to assess differences in perceived usability and museum experience. The subsequent qualitative phase then provided deeper insights into user perceptions, pre-visit intentions, sharing propensity, and the emergent curiosity satisfaction paradox, which explained the quantitative outcomes.

3.1.2 Application Development Overview

The bespoke VR applications (VR-TSM and VRG-TSM), crucial for the experimental evaluation, were developed over six months following the Mobile Application Development Lifecycle (MADLC) model (Raus et al., 2016). Unity 3D (version 2021.3.16f1) was used to create custom 3D assets, application logic (e.g., teleportation, quizzes), and the museum environments. The final applications were optimised for smartphone-based VR viewers.

To investigate the impact of digital heritage delivery, two distinct virtual reality applications were developed based on the Chinese History Museum in Sarawak, Malaysia.

3.2 Application Design and Key Features

To investigate the impact of digital heritage delivery, two distinct virtual reality applications were developed based on the Chinese History Museum in Sarawak, Malaysia.

3.2.1 Gamified VR Condition (VRG-TSM)

The VRG-TSM application utilised a Level-Based Pedagogical Structure designed to transform passive observation into an active, goal-oriented learning experience. To mitigate the risks of cognitive overload or distraction often associated with gamification (López & Tucker, 2019; Almeida et al., 2023), the application employed a Scaffolding Design across five distinct levels, each featuring a unique maze (unlockables) layout (see Figures 2, 3, 4 and 5):

- Content Scaffolding: The experience was structured to mirror a progressive learning curve. It transitioned from foundational knowledge—raw textile materials (Level 1) and manufacturing processes (Level 2)—to complex cultural artefacts, specifically the traditional costumes of Sarawak's diverse ethnic groups, including the Orang Ulu, Iban, Melanau, Bidayuh, Malay, Chinese, and Indian communities (Levels 3–5).

- Knowledge-Gated Unlockables: Advancement was governed by Information-Seeking Mechanics. To "unlock" subsequent levels, participants were required to locate specific 3D artefacts and synthesise information from their descriptions to answer a knowledge-based question. A correct response triggered a "Treasure" interaction, which served as a gateway. This ensured that progression was intrinsically tied to information acquisition rather than mere gameplay.

- Variable Virtual Rewards: Upon successfully navigating the levels, players received virtual tokens featuring authentic Sarawakian cultural motifs. These were distributed via a "lucky draw" mechanic to provide Variable Ratio Reinforcement, a strategy intended to maintain engagement and provide a sense of cultural appreciation without detracting from the museum's educational mission.

Figure 2. Instructions appear to the users at the beginning of the level.

Figure 3. Instructions appear to the users at the beginning of each level.

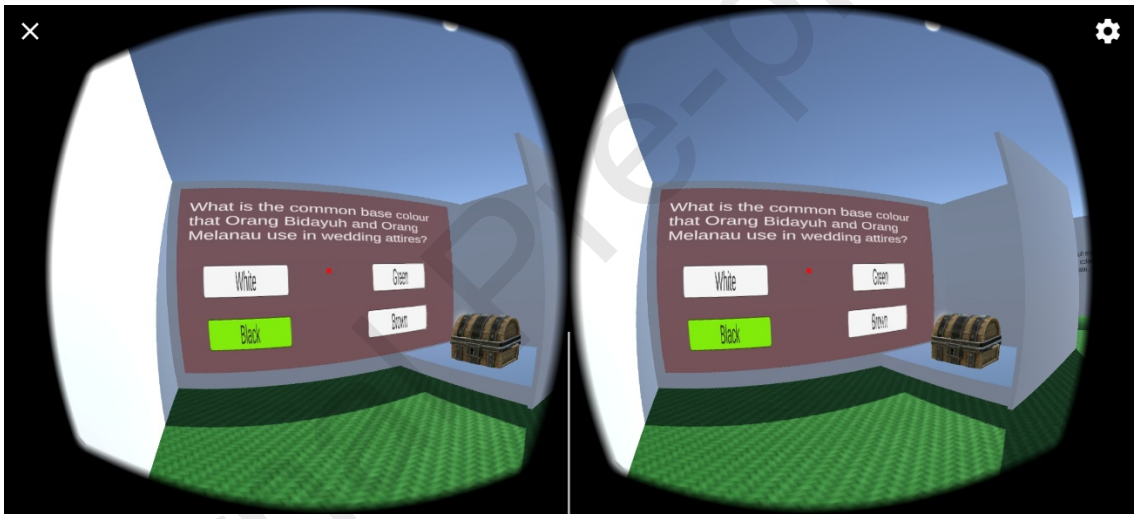

Figure 4. Example of quizzes in each level and the treasure chest.

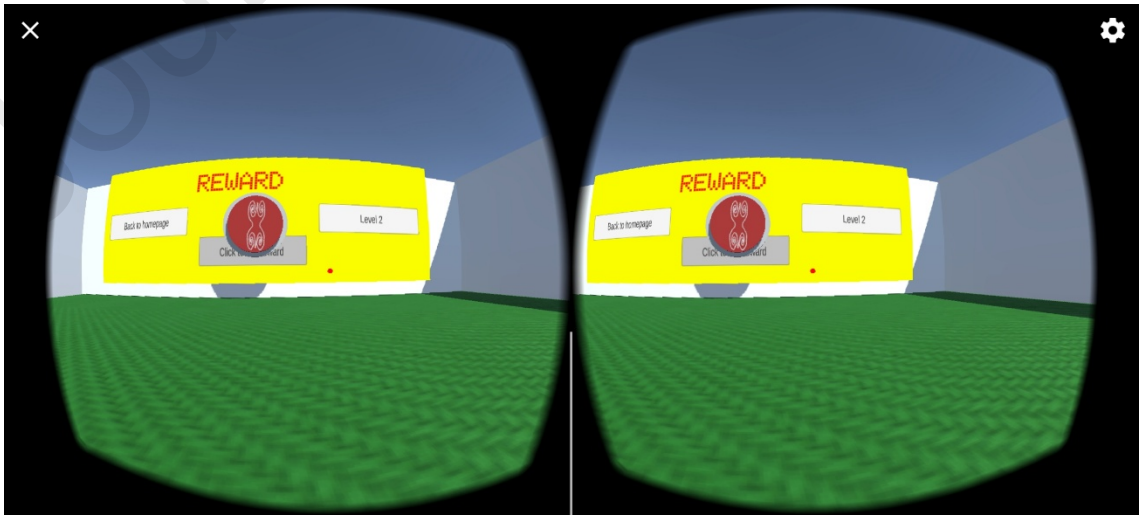

Figure 5. Tokens (Rewards) available for each level using traditional Borneo motifs

3.2.2 Baseline VR Condition (VR-TSM)

The VR-TSM application served as an immersive baseline to isolate the impact of 360-degree immersion from gamification. This version offered a non-gamified experience where users could freely explore 3D exhibits and environments at their own pace without interactive goals, challenges, or rewards (see Figures 6, 7 and 8).

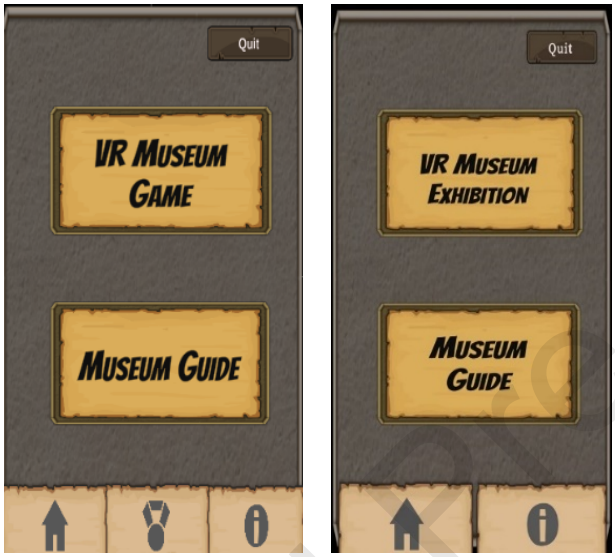

Figure 6. An example of the 2D layout of the VR-gamified museum app and VR museum app.

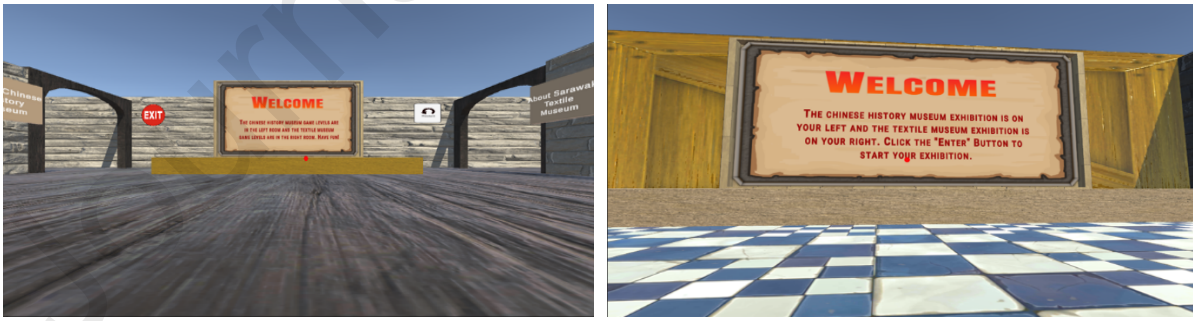

Figure 7. An example of the 3D layout of the VR-gamified and VR museum apps.

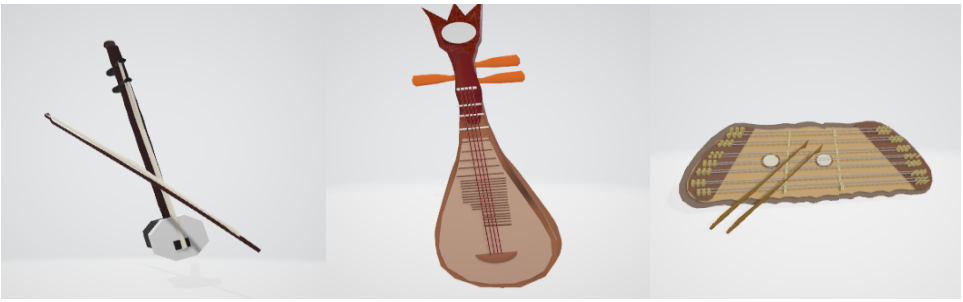

Figure 8. An example of 3D Exhibits.

3.3. Experimental Design and Procedure

3.3.1. Participants and Recruitment

A total of 90 Malaysian domestic visitors were recruited over four months using convenience sampling at the Chinese History Museum in Sarawak. Participants were randomly assigned to one of three groups: Website (N = 30), VR Museum App (VR-TSM App, N = 31), and VR-Gamified Museum App (VRG-TSM App, N = 29) (Table 1). Recruitment targeted recent physical visitors or established museum patrons, ensuring a relevant pool for evaluating pre-visit engagement tools.

Inclusion criteria required participants to be over 18 years old and proficient in using VR/websites. Exclusion criteria included conditions that predispose individuals to VR sickness or dizziness. A power analysis for a one-way ANOVA (G*Power 3.1.9.7) indicated that a sample size of N = 90 was sufficient to detect a medium-to-large effect size (f = 0.33) with 80% power at an alpha level of 0.05. This approximation was used as a guide due to the complexity of power analyses for non-parametric tests, which were later employed due to data non-normality.

Participants were randomly assigned to one of three experimental groups:

1. Website Group (Control): Interacted with the official Chinese History Museum website (https://museum.sarawak.gov.my/).

2. VR Museum App Group (VR-TSM): Interacted with the VR-only museum application, using compatible smartphones (e.g., Samsung Galaxy S8, Huawei P20) with Google Cardboard VR viewers.

3. VR-Gamified Museum App Group (VRG-TSM): Interacted with the VR-gamified museum application, also using compatible smartphones (e.g., Samsung Galaxy S8, Huawei P20) with Google Cardboard VR viewers.

3.3.2. Data Collection Procedure

All participants received a standardised briefing and instructions. Each had a 30-minute interaction session, during which the researcher conducted unobtrusive observations to inform later qualitative inquiry.

Post-session, participants completed a questionnaire. The System Usability Scale (SUS) (Brooke, 1996) was administered to all groups. The Museum Experience Scale (MES) (Othman et al., 2011) was administered exclusively to the VR and VRG-TSM groups, as its focus on immersive constructs was less applicable to the static website. This limited a direct quantitative comparison of overall experience across all three platforms, but qualitative data provided crucial cross-platform insights. Additionally, open-ended questions assessed pre-visit intentions and sharing propensity. Semi-structured interviews (each lasting 30 minutes) were conducted to collect rich, qualitative data on perceived strengths, weaknesses, and factors influencing the curiosity-satisfaction paradox. All interviews were audio-recorded with consent and transcribed verbatim.

3.3.3 Mapping Gamified Element

To ensure that the gamification elements supported rather than distracted from the museum's educational objectives, each mechanic was designed with a specific pedagogical goal (see Table 2 for a detailed mapping of elements to functions).

3.4. Data Analysis

Quantitative data from SUS and MES were processed using JASP (Version 0.16.1). Descriptive statistics, detailed demographics and scores. Cronbach's alpha was used to validate the reliability of MES (α = 0.87).

Normality was assessed using Shapiro-Wilk tests and visual inspection of Q-Q plots. For SUS scores, the Website (p = .558, W = .971) and VR-TSM (p = .387, W = .963) groups satisfied normality assumptions, whereas the VRG-TSM group showed a significant violation (p < .001, W = .842). Skewness and kurtosis for VRG-TSM were -1.42 and 1.88, respectively, indicating a substantial left skew. Given this significant violation in one treatment arm and similar non-normality across three of the four MES dimensions (e.g., Engagement, p = .003), nonparametric Kruskal-Wallis H tests were used for all primary platform comparisons to ensure consistency and prevent Type I error inflation.

Significant overall effects were followed by Dunn's post-hoc tests with Bonferroni correction (α_{adjusted} to .017) to avoid Type I error inflation. Effect sizes were reported as epsilon-squared (ϵ^2) for the Kruskal-Wallis test (values of .01, .06, and .14 represent small, medium, and large effects, respectively) and rank-biserial correlations (r) for the post-hoc Mann-Whitney U tests, interpreted according to Cohen's guidelines: .10 (small), .30 (medium), and .50 (large). Mann-Whitney U tests were also used to compare the two VR groups on MES dimensions.

Qualitative data from open-ended questions and interviews underwent thematic analysis (Braun & Clarke, 2006). Two coders reviewed transcripts and assigned codes for RQ1-RQ5. The process, including familiarisation, coding, searching for and reviewing themes, defining, and reporting, systematically identified patterns and insights. Interrater reliability was ensured (κ=0.85). Themes, supported by illustrative quotes, were directly aligned with the conceptual framework, exploring how the paradox moderated pre-visit intentions.

3.5 Ethical Considerations

The study received institutional ethics review board approval (XXX). Participants received an Information Sheet detailing the purpose, procedures, minimal risks, confidentiality, and withdrawal rights. Written informed consent was secured; all data were anonymised and stored securely. A debriefing session was conducted after data collection, providing participants with information about Malaysia's digital adoption landscape and the local relevance of the study.

4.0 Results

This section presents the study's mixed-methods findings. Quantitative results from the SUS and MES address aspects of RQ2 and the corresponding hypotheses. Qualitative insights from interviews and open-ended questionnaire responses address the design elements (RQ1), pre-visit intention (RQ3), sharing propensity (RQ4), and the emergent 'curiosity satisfaction paradox' (RQ5).

4.1. Quantitative Findings: Usability and Museum Experience (Addressing RQ2, H1, H2, and H3)

4.1.1. System Usability Scale (SUS) Results (Addressing H1 and H2)

The SUS was administered to all 90 participants. Average SUS scores were: Website (*M*=61.75, SD=15.23), VR-TSM App (*M*=69.19, *SD*=10.81), and VRG-TSM App (*M*=72.41, *SD*=19.02). Mean ranks were 34.67 (Website), 46.02 (VR-TSM App), and 55.82 (VRG-TSM App).

Prior to the main analysis, the distribution of SUS scores was examined (Table 3). The Website (W = .971, p = .558; skewness = -0.12) and VR-TSM (W = .963, p = .387; skewness = -0.45) groups met normality criteria. However, the VRG-TSM group was significantly non-normal (W = .842, p < .001), displaying a substantial left-skew (skewness = -1.42, kurtosis = 1.88), likely due to a ceiling effect where many participants reported maximum usability scores .Given these violations and similar non-normality in MES dimensions (e.g., Engagement, p = .003), a Kruskal-Wallis H test was conducted. The test revealed a statistically significant difference in SUS scores among the three platforms, $\chi^2(2, N=90)=9.778$, $p = .008$, the overall effect size, rank epsilon-squared ($\epsilon^2 = .110$), indicated a medium effect.

Post-hoc Dunn's Tests with Bonferroni correction ($_{adjusted}$ α=0.017) identified specific group differences, presented in Table 4 with rank-biserial correlations (*r*) as effect sizes.

The post-hoc analysis revealed that the VR-Gamified App had significantly higher perceived usability than the Website, $Z = 3.120$, $p = .005$, with a medium-to-large effect size ($r = .424$). In contrast, the difference between the VR Museum App ($M_{rank} = 46.02$) and the Website ($M_{rank} = 34.67$) was not significant ($Z = 1.743$, p = .244, r = .302), thus H1 is not supported. This indicates that while VR offers improvements, this specific VR-only implementation did not significantly enhance usability over the

Website. Additionally, perceived usability did not differ significantly between the VR-Gamified App and the VR Museum App (Z =1.416, p = *.470,* r = .257), suggesting that gamification elements did not lead to a statistically significant usability improvement over the non-gamified VR app.

In summary, only the VR-Gamified App demonstrated superior perceived usability compared to the traditional museum website, supporting H2 but not H1.

4.1.2. Museum Experience (Hypothesis H3)

The normality of the MES dimensions was assessed for the VR-TSM (n=31) and VRG-TSM (n=29) groups. Shapiro-Wilk tests indicated that Engagement and Knowledge/Learning significantly deviated from normality ($p < .05$) (Table 5). Meaningful Experiences also showed non-normality in the VRG-TSM group ($p = .042$). While Emotional Connection met the criteria for normality in both groups ($p > .05$), the overall pattern of non-normality across the scale, compounded by the negative skewness (ranging from -0.72 to -1.21), necessitated the use of non-parametric Mann-Whitney U tests for all MES comparisons to ensure statistical integrity. Results, including effect sizes (r), are presented in Table 6.

Statistical analyses revealed no significant differences between the VR-TSM App and VRG-TSM App groups for any of the four MES dimensions. Engagement (U =369.500, p=.230, r =−.178), Meaningful Experiences (U =402.000, p =.483, r =−.118), Knowledge and Learning (U =351.000, p =.139, r =−.219), and Emotional Connection (U =412.500, p =.587, r =−.082) all showed non-significant differences with small effect sizes. These consistently small to very small effect sizes fail to support H3, which posits that gamification would significantly enhance the museum experience. This suggests that VR's immersive quality alone may provide a highly engaging experience, making additional gamification elements less effective in significantly enhancing the perceived experience as measured by the MES. A

4.2. Qualitative Findings (Addressing RQ1, RQ3, RQ4, and RQ5)

Semi-structured interviews with all 90 participants and open-ended questionnaire responses provided rich, in-depth qualitative insights. Thematic analysis explored pre-visit intention (RQ3), sharing propensity (RQ4), and critically, the emergence of the 'curiosity satisfaction paradox' (RQ5). These findings also elucidated user-perceived strengths and weaknesses of the VR-gamified museum application's design elements in stimulating pre-visit engagement (RQ1).

4.2.1. Pre-Visit Intention (Addressing RQ3)

Participants were asked about their likelihood of physically visiting the Chinese History Museum. In the Website Group, 20 of 30 expressed some interest, but 10 were not sufficiently drawn to it. Disinterest stemmed from the website's static, text-heavy nature, which failed to generate curiosity or visual appeal. One participant commented, "There are too many words on the website and no photos that attract the reader." Another noted, "The website is quite boring... not many graphics that attract the reader to visit the museum." This suggests the Website's limitations in fostering strong pre-visit intention, highlighting a key design weakness.

In contrast, all 31 participants in the VR-TSM Group expressed a strong desire to visit the physical museum. This unanimous positive response highlights the significant potential of VR immersion in inspiring physical visit intentions. Participants often described the VR experience as a compelling 'teaser', sparking a desire for 'more' or 'genuine' interaction. For example, one participant stated, "The VR app was interesting, it made me curious to see the real artefacts, to feel the atmosphere of the museum." Another noted, "It was like a preview, now I want to go and experience it in person." These insights align with the positive usability scores for VR apps compared to the Website, illustrating VR immersion's clear strength in fostering interest.

The VRG-TSM Group also showed high physical visitation interest, with 28 of 29 participants attracted by the interactive, gamified, and immersive experience. Challenges and rewards were key to deepening engagement. A participant noted, "The game made learning fun. I felt I really earned the knowledge, and now I want to visit the museum." Another added, "I liked the challenges; it was exciting. It makes me want to visit the real place." Overall, the virtual experience sparked curiosity and desire for real-world visits, positively influencing pre-visit intent, demonstrating strong engagement despite no significant quantitative differences in usability or overall experience compared to the VR-only app

4.2.2. Propensity to Share the Digital Platforms (Addressing RQ4)

Qualitative feedback indicated participants' likelihood of sharing. In the Website Group, 24 of 30 would share, though four would not, and two would only share if asked, suggesting a baseline informational utility. The VR Museum App (VR-TSM) Group demonstrated a unanimous willingness to share (among all 31 participants), highlighting its value as an engaging promotional tool, particularly for international audiences. As one participant stated, "I would definitely share this. It's a unique way to see a museum, especially for people who can't travel easily."

The VR-Gamified Museum App (VRG-TSM) Group exhibited strong enthusiasm for sharing, with 28 of 29 participants willing to recommend it. Its "fun" and "interactive" features were key to its social appeal. Participants called it 'awesome,' with one commenting, "I'd tell my friends to try the maze. It's an adventure." Another noted, "It's engaging and perfect for social media sharing." The high sharing propensity across both VR apps, especially VRG-TSM, suggests their potential as effective organic promotional tools, driven by positive UX

4.2.3. The 'Curiosity Satisfaction Paradox' (Addressing RQ5)

A paradoxical finding emerged from the VRG-TSM group regarding pre-visit intentions. While most participants felt motivated to make a physical visit, two out of the 29 reported that their immersive virtual experience fully satisfied their curiosity, reducing their desire to visit in person. Participant A explained: "Honestly, after going through the maze and answering all the questions, I feel like I've learned everything about the exhibits. It was so comprehensive that I no longer feel the need to visit the physical museum. My curiosity is satisfied." Participant B echoed this: "The VR game was really good, I spent a lot of time in it. It was like I had already visited the

museum. Maybe if there were something else, I would go. But for now, I feel like I've seen enough."

This qualitative observation provides initial evidence for the 'curiosity satisfaction paradox', suggesting that for a small subset of users, a highly immersive and comprehensive virtual museum experience can inadvertently substitute, rather than precede, a physical visit. While observed in a limited number of participants, this phenomenon warrants further in-depth investigation and represents a nuanced design consideration for pre-visit stimulation.

Qualitative findings identify key user-perceived strengths and weaknesses of digital museum platforms, directly addressing RQ1. VR applications, particularly the VR-gamified app, excel in boosting pre-visit intention through immersive 'teaser' effects and engaging, enjoyable learning experiences. They also showed high sharing propensity due to novelty, interactivity, and perceived adventure. Conversely, the static, text-heavy traditional Website was a weakness, failing to spark physical visit curiosity. Notably, the emerging 'curiosity satisfaction paradox' in the VR-gamified app suggests a design weakness where virtual thoroughness might unintentionally satisfy curiosity, reducing real-world visit motivation.

5.0 Discussion

This study employed a mixed-methods approach to compare digital platforms and their strategic potential for museums as tourism attractions. The findings offer both confirmations and new insights into how technology can be leveraged for visitor engagement and promotion, while also introducing a critical paradox that warrants a re-evaluation of current digital strategies.

5.1. Discussion of Quantitative Findings: Implications for Visitor Management and Marketing

The quantitative results from the SUS and MES provided direct platform comparisons with significant implications for visitor management and destination marketing. Hypothesis 2 (H2) was supported, indicating the VRG-TSM App was perceived as significantly more usable than the Official Museum Website. Post-hoc analysis showed its significantly higher usability (p=.005) and a large effect size (r =.424). This strong practical difference confirms that immersive and gamified technologies can deliver a superior user experience, which is a foundational requirement for successful adoption and a key driver of positive brand perception in the tourism sector (Tongpaeng et al., 2024; Sangamuang et al., 2025).

Conversely, Hypothesis 1 (H1) was not supported, showing no statistically significant difference in perceived usability between the VR-only App and the Website (p=.244). This highlights that simply adopting a novel technology like VR is not a guarantee of improved user experience or market competitiveness. The absence of explicit guidance or gamified goals in the VR-TSM App might have made its interface less intuitive or more challenging than a familiar website, underscoring the need for meticulous design beyond just a "wow factor" and highlighting the risk of increased cognitive load (Li et al., 2024).

The most notable quantitative result was the lack of any statistically significant differences in museum experience when comparing the VRG-TSM App to the VR-TSM App (H3 not supported). This finding challenges the conventional assumption that gamification will universally improve the visitor experience beyond the baseline engagement provided by VR immersion alone. The consistently small effect sizes across all MES dimensions strongly suggest that the specific gamification elements, as implemented, did not yield a practically meaningful enhancement. This can be explained by several factors with direct implications for tourism strategy: VR's inherent novelty might create a "ceiling effect" for the MES, where additional features provide diminishing returns. The effectiveness of gamification is also highly dependent on sophisticated design and deep integration (Huang et al., 2025; Stein et al., 2024). This finding is crucial for tourism managers, as it indicates that investment in gamification for VR platforms should be guided by careful design and testing, not a blind assumption of benefit.

5.2. Discussion of Qualitative Findings: Precursors, Promotion, and the Paradox of Curiosity

The qualitative findings provided crucial contextual depth, illuminating user intentions and perceptions beyond quantitative scales, directly addressing the strategic impact of digital platforms on tourist behaviour.

5.2.1. Pre-Visit Intention (Exploring RQ3)

Consistent with the Theory of Planned Behaviour (TPB) (Ajzen, 1991), participants' positive attitudes toward the VR platforms strongly influenced their pre-visit intention. Both VR apps, unlike the static website, acted as a powerful "preview" or "teaser," increasing curiosity to "see the real artefacts" and "feel the atmosphere." This highlights the immense potential of immersive digital experiences as a destination marketing tool, capable of turning virtual interest into real-world visits. The gamified elements in the VRG-TSM App further amplified this desire, making learning "fun" and creating a sense of "earning the knowledge," which translated into a heightened desire for further exploration of the actual museum

5.2.2. Propensity to Share the Digital Platforms (Addressing RQ4)

The high propensity to share VR applications, particularly the VRG-TSM App, underscores their potential as organic promotional channels for tourism attractions. The engaging, gamified experiences resonated, prompting participants to recommend them to others. This aligns with experiential consumption theory (Pine & Gilmore, 2013), where memorable experiences foster word-of-mouth (Wang et al., 2025). The gamified app, perceived as an "adventure" and an "awesome game," effectively tapped into social sharing motivations, enhancing the museum's brand outreach and digital virality.

5.2.3. The 'Curiosity Satisfaction Paradox' (Exploring RQ5)

A critically important qualitative finding for the tourism industry was the emergence of the 'curiosity satisfaction paradox.' Observed in a small subset of the VRG-TSM group, this finding revealed that the highly comprehensive and engaging virtual

experience had "satisfied all [their] curiosity," reducing their perceived need for a physical visit. This observation significantly nuances the "teaser" effect and provides empirical evidence for the substitution effect of virtual tourism. It aligns with nascent discussions about how comprehensive virtual realities could displace, rather than drive, physical travel (Pantelidis et al., 2024; Jiang et al., 2025). This paradox highlights a delicate strategic balance that museums must strike: digital content should be engaging enough to attract visitors but not so comprehensive as to serve as a complete substitute for the physical experience. While these accounts offer strong initial qualitative support for the paradox, where comprehensive virtual engagement inadvertently satisfies curiosity and reduces physical visit motivation, the phenomenon's characteristics, frequency of occurrence, and underlying triggers remain to be quantified in future work

The superior usability of the VRG-TSM application ($p = .005$) suggests that integrating knowledge-gated unlockables functioned as an effective instructional scaffold, focusing attention rather than causing distraction (López & Tucker, 2019). However, this very success in providing a 'complete' and 'rewarding' journey may inadvertently lead to narrative closure. In a museum context, if completing 'Level 5' feels like a final chapter, the user may perceive the educational journey as finished, satisfy their information-seeking goals, and experience a diminished drive to seek out physical artefacts.

Furthermore, the Curiosity Satisfaction Paradox may be influenced by Malaysian cultural attitudes toward 'social outings.' In collectivist societies like Malaysia (Hofstede, 2001; Hofstede et al., 2010), museum-going is often a communal, social activity rather than a purely individual educational pursuit (e.g., Chan, 2009; Othman et al., 2021; Othman et al., 2022). If the VR experience is perceived as a complete individual fulfilment of curiosity, it may inadvertently satisfy the 'informational' need, even if the 'social' need for a physical visit remains. This suggests that the impact of VR on visit intention is not just a technological question, but a cultural one involving how different societies value physical presence versus digital representation.

In Malaysia's highly collectivist society (Hofstede, 2010), museum visitation frequently serves as a communal social activity, such as family or group outings for shared cultural bonding, rather than a purely individualistic pursuit of knowledge (Chan, 2009; Othman et al., 2021, 2022). While a comprehensive VR experience may fully satiate individual informational curiosity and personal learning goals, it is less equipped to fulfil the relational and social dimensions (e.g., group interaction, shared atmosphere) that often motivate physical visits in collectivist contexts. This decoupling implies that the curiosity satisfaction paradox may be culturally moderated: in collectivist settings like Malaysia, virtual satisfaction of personal curiosity might not substantially diminish intentions for physical visits if underlying social motivations remain unmet digitally

5.3. Theoretical and Practical Implications

This study makes several critical theoretical and practical contributions that advance the understanding of digital engagement in tourism. Theoretically, it offers a novel perspective by extending established frameworks. It refines Experiential Marketing and Flow Theory, providing empirical evidence that while VR delivers a strong

experiential foundation, the added gains from gamification may diminish, pointing to possible saturation points in user experience. Crucially, the qualitative exploration of the 'curiosity satisfaction paradox' introduces a vital new dimension to tourism research. It extends the Theory of Planned Behaviour (TPB) by demonstrating that a highly immersive virtual experience can, for a subset of users, act as a substitute for a physical visit, rather than a precursor. This provides empirical qualitative evidence that enriches the academic discourse on virtual tourism substitution effects (Anaya-Sánchez et al., 2024; Pantelidis et al., 2024; Jiang et al., 2025).

Moreover, these patterns suggest cross-cultural boundary conditions for the paradox. In more individualistic societies, highly immersive virtual experiences may more readily substitute for physical visits by fully addressing personal curiosity needs. In contrast, collectivist cultures, such as Malaysia's, may exhibit greater resilience to substitution effects, as social and relational drivers (e.g., group outings) sustain physical intentions despite virtual satiation of individual curiosity. Comparative cross-cultural studies would be valuable to test these moderators and enhance generalizability beyond the Malaysian context.

From a practical perspective, these findings offer several actionable insights for destination and visitor management. First, museums should prioritise investing in immersive digital experiences, as both VR applications were powerful tools for fostering pre-visit intent and promoting sharing. Second, the study provides a nuanced guide on gamification; while it may not quantitatively enhance the overall museum experience over VR-only, it significantly improves usability and promotes virality, making it highly valuable for specific marketing objectives. Third, and most importantly, museums must actively manage the 'curiosity satisfaction paradox.' Strategies could include emphasising exclusive physical exhibits, providing behind-the-scenes content, or ensuring virtual tours are positioned as a dynamic supplement to, not a static substitute for, the in-person experience.

6. Conclusion

This mixed-methods study compared the strategic value of VR-gamified, VR-only, and traditional website platforms for visitor engagement in the cultural heritage sector. Our findings demonstrate that a VR-gamified application significantly enhances perceived usability compared to a traditional website ($p=.005$), showcasing the transformative potential of immersive technologies. Both VR applications acted as powerful marketing tools for driving pre-visit intentions and promoting sharing, highlighting their efficacy as a "teaser" for physical engagement.

However, the study also provided crucial insights into the nuanced role of gamification. While the VR-gamified app's usability was superior to the website, its gamified elements did not significantly enhance the overall museum experience compared to the VR-only app. This suggests that in an already immersive environment, the added benefits of simple gamification may be subtle. Crucially, this research introduces the novel 'curiosity satisfaction paradox,' a phenomenon that future studies should quantitatively operationalise (e.g., via scale development) to evaluate its scope and design implications. This paradox poses a significant strategic

challenge for tourism managers seeking to leverage virtual content as a precursor, not a substitute, for physical engagement. Overall, this study emphasises that while VR and gamification can enrich cultural heritage experiences and inspire visitation, their implementation requires a nuanced strategy, particularly attending to cultural moderators such as collectivism, to ensure digital platforms complement, rather than replace, physical museum visits

7. Limitations and Future Research

This study has several limitations that provide clear avenues for future research. First, as a cross-sectional study, the data were collected at a single point in time, which restricts our ability to infer causality or assess the long-term effects of the applications. The use of a convenience sample also limits the generalizability of our findings to a broader population of museum visitors. While the power analysis was carefully conducted, the eventual use of non-parametric tests means the study may have been underpowered to detect smaller, yet practically meaningful, effects. For instance, the non-significant difference between the VR-TSM App and the Website (p = .244) with a medium effect size (r = .302) suggests that a larger sample might have revealed statistical significance.

Second, the specific gamification elements implemented (maze/level navigation, quizzes) may not represent the full range of available mechanics. Different designs could yield varying user experience outcomes. Third, the 'curiosity satisfaction paradox' was identified qualitatively in a small subset of participants (n=2 in the VRG-TSM group), providing compelling preliminary evidence of its potential existence but precluding reliable estimates of prevalence, causal mechanisms, or boundary conditions. As an emergent phenomenon observed in this study, it remains illustrative rather than definitively established. To advance understanding, future research should prioritise quantitative operationalisation and validation. This could involve developing a dedicated measurement scale (e.g., multi-item Likert-scale items assessing post-virtual curiosity satiation, perceived completeness of the experience, and its inverse relationship to physical visit intentions) or controlled experimental designs (e.g., manipulating VR tour completeness, partial/teaser vs. comprehensive/full immersion, to test substitution effects systematically). Such approaches would enable examination of psychological triggers (e.g., immersion depth, narrative closure, individual vs. social curiosity fulfillment), prevalence across larger and more diverse samples, and moderators such as cultural context.

Moreover, this study was conducted with a sample of participants in Malaysia, a context characterised by specific levels of digital literacy and cultural heritage values. The results may not be directly generalisable to regions with higher VR saturation (where the 'Novelty Effect' is lower) or to cultures that place a different premium on physical versus digital artefacts. Additionally, the sample consisted largely of urban-dwelling individuals with consistent technology interaction; the results may differ significantly among rural populations or older age cohorts with different levels of technological self-efficacy.

Lastly, our study focused solely on stated intentions for a physical visit rather than tracking actual museum attendance.

Building on these findings, future research should:

1. Conduct larger, more diverse studies with random sampling to enhance generalizability and adequately power the detection of subtle effects.
2. Employ longitudinal designs to evaluate the long-term impact of VR-gamified apps on user behaviour and to assess if stated intentions translate into actual physical visits.
3. Explore alternative gamification mechanics (e.g., social gamification, narrative-driven games) and their impact on both the user experience and visit intentions.
4. To move beyond the qualitative identification of the Curiosity Satisfaction Paradox, future research must prioritise the quantitative operationalisation of this construct. This includes the development of a 'Virtual Satiation Scale' to measure the threshold at which digital immersion transitions from a driver of interest to a substitute for physical presence. These would enable statistical modelling (e.g., moderation/mediation analyses within extended TPB frameworks) and provide museum practitioners with validated tools to design digital content that optimises pre-visit stimulation without unintended substitution.

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References

Abushariehh, I., Ruiz Mafe, C., & Küster, I. (2025). A Decade of Innovation: A Bibliometric Analysis of Advergames and Gamification in Tourist Destinations. Journal of Theoretical and Applied Electronic Commerce Research, 20(1), 34.

Agustini, K., Putrama, I. M., Wahyuni, D. S., & Mertayasa, I. N. E. (2023). Applying Gamification Technique and Virtual Reality for Prehistoric Learning toward the Metaverse. International Journal of Information and Education Technology, 13(2). http://www.ijiet.org/vol13/IJIET-V13N2-1802-IJIET-5586.pdf

Ajzen, I. (1991). The theory of planned behavior. Organisational behavior and human decision processes, 50(2), 179-211.

Almeida, C., Kalinowski, M., Uchôa, A., & Feijó, B. (2023). Negative effects of gamification in education software: Systematic mapping and practitioner perceptions. Information and Software Technology, 156, 107142.doi: 10.1016/j.infsof.2022.107142

Anaya-Sánchez, R., Rejón-Guardia, F., & Molinillo, S. (2024). Impact of virtual reality experiences on destination image and visit intentions: the moderating effects of immersion, destination familiarity and sickness. International Journal of Contemporary Hospitality Management, 36(11), 3607-3627.

Anwar, M. S., Yang, J., Frnda, J., Choi, A., Baghaei, N., & Ali, M. (2025). Metaverse and XR for cultural heritage education: applications, standards, architecture, and technological insights for enhanced immersive experience. Virtual Reality, 29(2), 51.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101.Alathas, H. (2018). How to Measure Product Usability with the System Usability Scale (SUS) Score. Retrieved June 23, 2020, from https://uxplanet.org/how-to-measure-product-usabilitywith-the-system-usability-scale-sus-score-69f3

Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7. Taylor & Francis.British Museum. (2025). Early Egypt. Retrieved from https://www.britishmuseum.org/collection/galleries/early-egypt

Chan, J. K. L (2009). The Consumption of Museum Service Experiences: Benefits and Value of Museum Experiences. Journal of Hospitality Marketing & Management, 18(2–3), 173–196. doi: 10.1080/19368620802590209

Chauhan, N., & Karthikeyan, A. (2025). Usage of Augmented Reality and Gamification Elements to Enhance Engagement and Learning Experiences in Heritage Tourism Sites: Case Studies and Insights. In Meaningful Tourism: Strategies and Future Development (pp. 31-52). Emerald Publishing Limited.

Chekembayeva, G., & Garaus, M. (2024). Authenticity matters: investigating virtual tours' impact on curiosity and museum visit intentions. Journal of Services Marketing, 38(7), 941-956Deng, N., Zhang, H., & Jiang, X. (2025). Transformation in the Digital Age: Factors Influencing Visitor Engagement in Virtual Museums. ACM Journal on Computing and Cultural Heritage.

Chen, Y., Shen, S., & Hua, M. (2024). Enhancing ancient architecture virtual learning tour through virtual embodiment: impact on immersion, engagement, and learning outcomes. In International Conference on Human-Computer Interaction (pp. 3-18). Cham: Springer Nature Switzerland.

Cheng, J., & Qian, J. (2025). Exploring the key factors influencing tourists' intention to use mobile AR educational applications from the perspective of structural equation modeling. npj Heritage Science, 13(1), 119.

Chernbumroong, S., Ariya, P., Yolthasart, S., Wongwan, N., Intawong, K., & Puritat, K. (2024). Comparing the impact of non-gamified and gamified virtual reality in digital twin virtual museum environments: a case study of wieng yong house museum, Thailand. Heritage, 7(4), 1870-1892.

Csikszentmihalyi, M. (1990). Flow: The psychology of optimal experience. Harper & Row.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.

Fauzi, H., Sharif, H. M., & Razak, R. A. (2022). Virtualisation of digitalised cultural assets to promote sustainable heritage tourism in Malaysia. International Journal of Environment, Architecture, and Societies, 2(02), 85-99.

Gibson, A., O'Rawe, M. (2018). Virtual Reality as a Travel Promotional Tool: Insights from a Consumer Travel Fair. In: Jung, T., tom Dieck, M. (eds) Augmented Reality and Virtual Reality. Progress in IS. Springer, Cham. doi: 10.1007/978-3-319-64027-3_7

Hofstede, G. (2001). Culture's consequences: Comparing values, behaviors, institutions and organizations across nations. (2nd ed.). Sage Publications

Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). Cultures and organizations: Software of the mind (3rd ed.). McGraw-Hill.

Huang, X., Li, Y., & Tian, F. (2025). Enhancing User Experiecne in Interactive Virtual Museums for Cultural Heritage Learning through Extended Reality: The Case of Sanxingdui Bronzes. IEEE Access.

Huotari, K., Hamari, J. A (2017). Definition for gamification: anchoring gamification in the service marketing literature. Electron Markets 27, 21–31 . doi: 10.1007/s12525-015-0212-z

International Council of Museums (ICOM). (2022). ICOM Definition of the Museum. Retrieved from https://icom.museum/en/resources/standards-guidelines/museum-definition/

Ivanov, R., & Velkova, V. (2025). Analysing Visitor Behavior to Enhance Personalised Experiences in Smart Museums: A Systematic Literature Review. Computers, 14(5), 191.

Jeon, S. W., Moon, S. J., & Ryu, G. H. (2022). Designing the museum gamification system. International Journal of Internet, Broadcasting and Communication, 14(2), 219-224.https://www.koreascience.or.kr/article/JAKO202215356051345.pdf

Jiang, C., Moghavvemi, S., & Phoong, S. W. (2025). Virtual reality's promise for eco-friendly adventures: a study on its role in fostering sustainable tourism and reducing environmental footprint. Information Technology & Tourism, 1-31.

Khalid, F. (2019). Incorporating the Elements of Computational Thinking into the Mobile Application Development Life Cycle MADLC Model. International Journal of Engineering and Advanced Technology, 8(5), 815-824.

Kluge-Pinsker, A., & Stauffer, B. (2021). Non-visitors: Who are they and what should we do about them?. Journal of Museum Education, 46(1), 61-73.

Kotsifakos, D., Karali, M. G., Katzola, E., Kravvari, A., & Douligeris, C. (2022). A Web Gamification Platform Inspired by the Maritime Tradition Museum in Perama, Greece, for Students in the Sector of Maritime Professions in Vocational Education and Training. European Journal of Engineering and Technology Research, 49-52.

Li, J., Zheng, X., Watanabe, I., & Ochiai, Y. (2024). A systematic review of digital transformation technologies in museum exhibition. Computers in Human Behavior, 108407.

Li Yi Fei, & Othman, M. K. (2024). Beyond Exhibits: Exploring Museum VR Adoption through a Validated UTAUT2 Model for Visitor Usage Behaviour. Journal of Cognitive Sciences and Human Development, 10(2), 1–18. doi: 10.33736/jcshd.7195.2024

Kruczek, Z., Gmyrek, K., Ziżka, D., Korbiel, K., & Nowak, K. (2024). Accessibility of cultural heritage sites for people with disabilities: a case study on Krakow museums. Sustainability, 16(1), 318.

Lei, M., Tan, S., & Gao, P. (2025). A Multidimensional Perspective on the Impact of Gamification on Visitors' Emotions and Revisit Intention in Virtual Museum Spaces: A Case Study of the Southern Han Mausoleums Museum. Buildings, 15(9), 1430.

Li, Y., Yang, R., Zou, J., Xu, H., & Tian, F. (2024). Human-Centric Virtual Museum: Redefining the Museum Experience Through Immersive and Interactive Environments. International Journal of Human–Computer Interaction, 1-12.

Lopez, C. E., & Tucker, C. S. (2021, July). Adaptive gamification and its impact on performance. In International conference on human-computer interaction (pp. 327-341). Cham: Springer International Publishing.

Malaysia Now (2022). Bringing Malaysia's museums out from the past. Available online. [https://www.malaysianow.com/news/2022/09/17/bringing-malaysias-museums-out-from-the-dregs-of-the-past

Marinho, A., Bittencourt, I. I., Dermeval, D., Santos, J., Challco, G., & Reis, M. (2025). How does the Mechanics of Competition and Collaboration Impact on Student's Flow Experience in a Gamified Educational Environment? An Experimental Study in Higher Education (under review). Technology, Knowledge and Learning, 30(1), 399-424.

Martinez, A.L., Carrera, A, & Iglesias, C. A.(2020).Empowering Museum Experiences Applying Gamification Techniques Based on Linked Data and Smart Objects. Applied Sciences, 10(16), 5419. doi: 10.3390/app10165419

Massari, F. S., Del Vecchio, P., & Degl'Innocenti, E. (2024). Past for Future–museums as a digitalised "interaction platform" for value co-creation in tourism destinations. European Journal of Innovation Management, 27(5), 1453-1474.4

Mazarakis, A., & Bräuer, P. (2023). Gamification is working, but which one exactly? Results from an experiment with four game design elements. International Journal of Human–Computer Interaction, 39(3), 612-627.

Nikolaou, P. (2024). Museums and the post-digital: Revisiting challenges in the digital transformation of museums. Heritage, 7(3), 1784-1800.

Nintendo (2013). The Louvre in the comfort of your home!. https://www.nintendo.com/en-gb/Games/Nintendo-3DS-games/Nintendo-3DS-Guide-Louvre-822301.html?srsltid=AfmBOorI5ToRkcD9BsVxejf2-4NQoCorNXPFA1cM75VkBPaSlEBkjgfw

Nofal, E., Panagiotidou, G., Reffat, R. M., Hameeuw, H., Boschloos, V., & Vande Moere, A. (2020). Situated tangible gamification of heritage for supporting collaborative learning of young museum visitors. Journal on Computing and Cultural Heritage (JOCCH), 13(1), 1-24.

Othman, M.K., Petrie, H., Power, C. (2011). Engaging Visitors in Museums with Technology: Scales for the Measurement of Visitor and Multimedia Guide Experience. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (eds) Human-Computer Interaction – INTERACT 2011. INTERACT 2011. Lecture Notes in Computer Science, vol 6949. Springer, Berlin, Heidelberg. doi: 10.1007/978-3-642-23768-3_8.

Othman, M. K., Aman, S., Anuar, N. N., & Ahmad, I. (2021). Improving children's cultural heritage experience using game-based learning at a living museum. Journal on Computing and Cultural Heritage (JOCCH), 14(3), 1-24.

Othman, M. K., Nogoibaeva, A., Leong, L. S., & Barawi, M. H. (2022). Usability evaluation of a virtual reality smartphone app for a living museum. Universal Access in the Information Society, 21(4), 995-1012.

Pantelidis, C., tom Dieck, M. C., Jung, T. H., Smith, P., & Miller, A. (2024). Place attachment theory and virtual reality: the case of a rural tourism destination. International Journal of Contemporary Hospitality Management, 36(11), 3704-3727.

Paschmann, J. W., Bruno, H. A., van Heerde, H. J., Völckner, F., & Klein, K. (2025). Driving Mobile App User Engagement Through Gamification. Journal of Marketing Research, 62(2), 249-273.

Pine, B. J., & Gilmore, J. H. (2013). The experience economy: past, present and future. In Handbook on the experience economy (pp. 21-44). Edward Elgar Publishing.

Raus, M.I.M., Canda, R., Azam, Z., Sariman, H. & Norsyam, W.M. (2016). The Development of FiTest for institutions of higher learning using Mobile Application Development Lifecycle Model (MADLC): From Identification Phase to Prototyping Phase. International Academic Research Journal of Business and Technology. 2. 77-84.

Ribeiro, M., Santos, J., Lobo, J., Araújo, S., Magalhães, L., & Adão, T. (2024). VR, AR, gamification and AI towards the next generation of systems supporting cultural heritage: Addressing challenges of a museum context. In Proceedings of the 29th International ACM Conference on 3D Web Technology (pp. 1-10).

Sanfilippo, F., Tataru, M., Hua, M. T., Johansson, I. J. S., & Andone, D. (2025). Gamifying cultural immersion: Virtual reality (vr) and mixed reality (mr) in city heritage. IEEE Transactions on Games. 1-20. doi: 10.1109/TG.2025.3553712

Sangamuang, S., Wongwan, N., Intawong, K., Khanchai, S., & Puritat, K. (2025). Gamification in virtual reality museums: Effects on hedonic and eudaimonic experiences in cultural heritage learning. Informatics, 12(1).doi: 10.3390/informatics12010027

Sharma, I., Kaur, H. J., Singh, S. P., & Aggarwal, A. (2025). Exploring Digital Destinations: A Three-Decade Bibliometric Journey Through Virtual Tourism Research. Tourism Review International, 29(2), 93-114. doi: 10.3727/194344225X17315216888952

Spierling, U., Bitter, J., Liu, Y., & Müller, T. (2023). Chances and limitations of immersive augmented reality for game-based learning in museums. In European Conference on Games Based Learning (pp. 643-650). Academic Conferences International Limited.

Stein, F., Guerreiro, J., Loureiro, S. M. C., & Rodrigues, M. B. (2025). Leveling up coolness: how VR gamification drives experiential values. Journal of Brand Management, 1-20.doi: 10.1057/s41262-025-00390-3.

Sukri, S., Daud, K. A. M., Razak, S. N. A., Ab Jabar, N., & Jamal, D. H. D. (2024). Visitor Satisfaction With Museum Management During The Covid-19 Pandemic: A Case Study Of The National Museum Of Malaysia. Planning Malaysia, 22.

Sun, W., Li, L., Liu, Y., Sun, F., & Zhu, Y. (2025). How Destination Image Building Tourists' Immersive Experience for Online Tour and Stimulate the Intention to Visit in Person. IEEE Access. doi: 10.1109/ACCESS.2025.3532457

Tham, A., Liu, Y., & Loo, P. T. (2025). Transforming museums with technology and digital innovations: a scoping review of research literature. Tourism Review, 80(3), 631-647. doi: 10.1108/TR-02-2023-0112.

Tongpaeng, Y., Nobnop, R., Wongwan, N., Homla, P., Intawong, K., & Puritat, K. (2024). Comparison of gamified and non-gamified mixed reality in enhancing museum visitor engagement, motivation, and learning outcome. Journal of Heritage Tourism, 19(6), 919-948. doi: 10.1080/1743873X.2024.2351852.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425-478.

Vinnakota, S., Mohan, M. D., Boda, M. J., Askarzai, W., Devkota, M. P., Shetty, M. S., ... & Choden, M. T. (2023). Venturing into virtuality: exploring the evolution, technological underpinnings, and forward pathways of virtual tourism. Educational Research (IJMCER), 5(6), 08-49.

Wang, J. (2024). Interaction and Exploration: How Digital Technology Contributes to Narrative Construction in Museums. In 2024 IEEE 7th Eurasian Conference on Educational Innovation (ECEI) (pp. 270-275). IEEE.doi: 10.1109/ECEI60433.2024.10510858.

Wang, X., Li, Y., & Liang, H. N. (2024). MagicMap: Enhancing Indoor Navigation Experience in VR Museums. In 2024 IEEE Conference Virtual Reality and 3D User Interfaces (VR) (pp. 881-891). IEEE. doi: 10.1109/VR58804.2024.00107

Wang, X., Liao, Y., Liu, C., & Zheng, J. (2025). Exploring determinants of visitor's e-WOM in the virtual art exhibition with an extended American Customer Satisfaction Index Model. Consumer Behavior in Tourism and Hospitality, 20(1), 38-56. doi: 10.1108/CBTH-04-2024-0149.

Yersüren, S., & Özel, Ç. H. (2024). The effect of virtual reality experience quality on destination visit intention and virtual reality travel intention. Journal of Hospitality and Tourism Technology, 15(1), 70-103. doi: 10.1108/JHTT-02-2023-0046.

Zeqiri, A. (2024). Virtual tourism as a substitute for physical tourism during COVID-19 pandemic. Environmental Economics and Policy Studies, 26(2), 125-144.doi: 10.1007/s10018-023-00382-0.

Zhang, Y., Zhang, B., Jang, W., & Pan, Y. (2024). Enhancing spatial cognition in online virtual museum environments: integrating game-based navigation strategies for improved user experience. Applied Sciences, 14(10), 4163. doi: 10.3390/app14104163

Zhang, Z. H., & Huang, H. C. (2025). Enhancing Sustainable Tourism Through Virtual Reality: The Role of Collectable Experiences in Well-Being and Meaning in Life. Sustainability, 17(13), 5809. doi: 10.3390/su17135809

Zhao, Y., Li, Y., Dai, T., Sedini, C., Wu, X., Jiang, W., ... & Lc, R. A. Y. (2025). Virtual reality in heritage education for enhanced learning experience: a mini-review and design considerations. Frontiers in Virtual Reality, 6, 1560594. doi: 10.3389/frvir.2025.1560594.

Table 1. Participant Criteria and Demographics

Criterion/Demographic Details	
Sample Size	N=90 (Website=30, VR-TSM=31, VRG-TSM=29)
Age	Between 18 and 69
Gender	82% female, 18% male

VR Experience	60% with prior use
Inclusion Criteria	Age >18, VR/Website usability
Exclusion Criteria	VR sickness, dizziness

Table 2. Mapping Gamification Elements to Educational Functions

Gamification Element	Practical Implementation	Educational/Psychological Function
Levels/Mazes	5 levels with distinct layouts based on ethnographic themes.	Content Scaffolding: Manages cognitive load by breaking complex history into digestible stages.
Knowledge Gates	Answering questions based on artefact descriptions to unlock levels.	Active Retrieval: Encourages participants to read and synthesise information rather than skimming.
Unlockables	"Treasure" and "Next Level" access granted upon correct answers.	Agency & Achievement: Provides immediate feedback and a sense of mastery over the subject matter.
Variable Rewards	Virtual tokens with authentic motifs distributed via "lucky draw."	Intrinsic Reinforcement: Maintains engagement and reinforces cultural appreciation without external pressure.

Note. The design of these elements follows the "Scaffolding" instructional framework and the Octalysis gamification model, intended to balance user challenge with informational attainment while avoiding the cognitive overload risks identified by López and Tucker (2019) and Almeida et al. (2023).

Table 3. Normality Distribution for SUS Scores

Group	Shapiro-Wilk (W)	p-value	Skewness	Kurtosis
Website	.971	.558	-0.12	-0.65
VR-TSM App	.963	.387	-0.45	0.12
VRG-TSM App	.842	< .001	-1.42	1.88

Table 4. Post-hoc Dunn's Test Results for SUS Scores Across Groups

Comparison	Mean Rank (Group 1)	Mean Rank (Group 2)	*Z*-score	*p*-value (Bonferroni)	Effect Size (*r*)	Significance ($p < .017$)
VRG-TSM vs. Website	55.82	34.67	3.12	.005	.424	Significant
VR-TSM vs. Website	46.02	34.67	1.743	.244	.302	Not Significant
VRG-TSM vs. VR-TSM	55.82	46.02	1.416	.47	.257	Not Significant

**Note: A Bonferroni corrected significance level of α=0.017 was used for pairwise comparisons. Effect sizes r:0.10= small,0.30= medium,0.50= large.*

Table 5. Normality Distribution for MES Dimensions

Dimension	Group	Shapiro-Wilk (W)	p-value	Skewness	Kurtosis
Engagement	VR-TSM	.912	.003	-1.15	1.10

Dimension	Group	Shapiro-Wilk (W)	p-value	Skewness	Kurtosis
	VRG-TSM	.921	.007	-1.02	0.85
Meaningful Exp.	VR-TSM	.965	.321	-0.42	-0.22
	VRG-TSM	.925	.042	-0.95	0.45
Knowledge/Learning	VR-TSM	.934	.139	-0.72	0.15
	VRG-TSM	.889	.012	-1.21	1.45
Emotional Conn.	VR-TSM	.968	.129	-0.38	-0.40
	VRG-TSM	.955	.056	-0.55	-0.10

Table 6: Mann-Whitney U Test Results for MES Dimensions Between VR-TSM App and VRG-TSM App

Dimension	Group	N	Mean Rank	*U* value	*p*-value	Effect Size (*r*)	Interpretation of *r*
Engagement	VR-TSM App	31	29.919	369.5	.23	-.178	Small effect
	VRG-TSM App	29	31.259				

Meaningful Experiences	VR-TSM App	31	28.968	402	.483	-.118	Very Small effect
	VRG-TSM App	29	32.138				
Knowledge/Learning	VR-TSM App	31	27.919	351	.139	-.219	Small effect
	VRG-TSM App	29	33.259				
Emotional Connection	VR-TSM App	31	28.396	412.5	.587	-.082	Very Small effect
	VRG-TSM App	29	32.71				

*Note: Effect sizes *r:* .10= small,.30= medium,.50= large.*