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Exploring the role of virtual reality in preserving and promoting traditional straw weaving crafts

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ABSTRACT

This study examines the acceptance of virtual reality (VR) technology in preserving traditional straw weaving by extending the Technology Acceptance Model (TAM) with cultural heritage authenticity and user engagement. Using a mixed-methods approach with surveys and follow-up interviews, data from 287 Chinese university students, artisans, museum visitors, and cultural enthusiasts were analyzed through PLS-SEM. Findings show that perceived ease of use strongly influences attitude ($\beta = 0.699$, $p < 0.001$), and attitude is the main predictor of behavioral intention ($\beta = 0.769$, $p < 0.001$). Perceived usefulness had a moderate effect on attitude ($\beta = 0.320$, $p = 0.004$), but perceived ease of use did not significantly affect usefulness, and neither authenticity nor user engagement significantly affected attitudes. High Heterotrait–Monotrait ratios indicate conceptual overlap, suggesting that authenticity may be embedded within usefulness, which was supported by interview data. The study highlights the need to adapt technology acceptance models to cultural heritage contexts.

1. Introduction

Traditional straw weaving is a craft that not only is a form of art but also holds cultural significance for numerous civilizations, tracing their history and heritage (Purwandaru, 2023). However, despite the importance of this craft, it suffers from a lack of practitioners, poor knowledge dissemination, and decreased interest from youth. Efforts to safeguard such forms of cultural heritage must blend modern design systems with nondestructive approaches (Yan et al., 2020) in areas were straw weaving aids in economic development in rural areas.

The use of virtual reality technologies in the cultural heritage field offers tantalizing possibilities to capture, instruct, digitally renew traditional crafts, and increase interaction with artefacts (Yang et al., 2024; Hu, 2024). The latest advancements in VR offer far greater preservation than mere digitization. VR culture enables the creation of three-dimensional spaces where real-life actions can be simulated for effective preservation and transmission of skills, allowing access for the public via 3D interfaces and enabling independent learning (Hu, 2024).

Research on cultural preservation increasingly considers the role of virtual reality (VR). However, studies rarely address user acceptance of VR in the specific context of straw weaving, a traditional craft at risk of decline. This study explores perceptions and acceptance of VR technologies for straw weaving conservation by applying quantitative methods within the framework of the Technology Acceptance Model (TAM). The research pursues three main objectives. First, it evaluates the level of user acceptance of VR as a tool for preserving straw weaving. Second, it identifies the key factors that motivate individuals to engage in VR-based learning of this craft. Third, it examines the extent to which VR influences the teaching and transmission of traditional weaving practices.

By addressing these objectives, the study contributes both theoretical and practical insights. Theoretically, it extends the application of TAM to the field of intangible cultural heritage, with a focus on a specific craft tradition. Practically, the findings will inform the development of instructional strategies that respect the cultural importance of straw weaving while responding to the requirements of contemporary educational systems worldwide. Ultimately, the research aims to design user

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guidelines that support the effective integration of VR into craft preservation efforts.

2. Literature review and hypothesis development

2.1. Perceived usefulness of VR in straw-weaving preservation

Perceived usefulness (PU), as defined by Davis (1989), captures the belief that users have about how their performance or the achievement of certain goals would be augmented using a specific technology. In the case of VR straw weaving preservation, PU refers to the perceptions and beliefs that users have about the extent to which VR technology improves their learning and understanding of traditional craft techniques.

Different studies have persistently coupled the importance of PU with an attitude toward technology, irrespective of the context. With respect to education, Bansah and Agyei (2022), alongside perceived convenience and effectiveness, reported that PUs also influence users' attitudes towards learning management systems. Furthermore, meta-analyses conducted on systems providing e-learning facilities have identified PU as one of the primary contributory factors for positive user attitudes, especially in cases where the technology is perceived to be beneficial (Bakı et al., 2018; Abdullah and Ward, 2016).

The relevance of PUs extends far beyond conventional learning systems. In new technologies such as self-driving cars, PU has been recognized as a significant factor influencing users' perceptions of technology (Zhang et al., 2019). This is particularly relevant for the use of VR in cultural heritage preservation because, in both cases, users are interacting with new and sophisticated technologies. Moreover, Aldosari (2012) argues that in healthcare settings, PU is the most important predictor of positive attitude formation when technology is assumed to improve quality and performance, which implies that showing the benefits of VR in craft preservation may increase its use.

The relevance of PU is evident in studies that focus on the adoption of technology by different groups of users. For example, older adults are an important target audience in traditional craft preservation. Pan and Jordan-Marsh (2010) reported that PU has the greatest impact on attitudes toward technology in this age group, which is helpful when practitioners' age diversity is considered. Furthermore, some studies within the sharing economy have shown that improving the PU is one of the most important factors for enhancing positive attitudes toward new services (Liu and Yang, 2018), providing the opportunity to assume that the use of VR in craft preservation can be enhanced by focusing on its functional benefits.

In addition, the Technology Acceptance Model claims that ease of use is an important precursor to perceived usefulness since systems that are simpler to operate are more useful (Davis, 1989). This connection has been continuously confirmed from different technological contexts, including the case of VR applications. Based on this extensive body of literature demonstrating the consistent positive relationship between PU and attitude formation across various contexts, we propose the following:

H1: Perceived ease of use positively influences the perceived usefulness of VR for preserving straw weaving.
H3: Perceived usefulness positively influences attitudes toward using VR for straw weaving preservation.

The hypotheses are numbered according to their conceptual grouping. H1 and H3 are presented together under perceived usefulness, while H2 is introduced subsequently in relation to attitudes. The numbering reflects thematic alignment with the literature rather than strict sequential order.

2.2. Perceived ease of use of VR systems

Numerous studies in various fields of technology have repeatedly proven that the PEOU concept has a distinct effect on technology acceptance in that it affects both perceived usefulness and use intention. Wang and Goh's (2017) meta-analysis of video game acceptance revealed that the PEOU is associated with both perceived utility and attitude construction, specifically in more functional contexts. This is particularly true in VR-based craft preservation, whereby technology is available for use in primary education and skill development.

It is well known in the literature related to educational technology that PEOU and perceived usefulness are correlated. Abdullah et al. (2016) noted in their research on e-portfolio systems that the PEOU strongly predicts perceived usefulness, meaning that if users perceive a system as simple to use, they value it more. Similarly, in mobile-based services, Verma and Sinha (2018) also reported that the PEOU was an important predictor of perceived usefulness. This illustrates how the perception of technology positively correlates with ease of use.

In the most recent secondary analyses, Ali and Warraich (2024) further reinforce the significance of the PEOU in technology adoption. This work reported, among other things, the strong effects of the PEOU on perceived usefulness and attitude construction toward digital libraries, which signifies the acceptance of new technological systems. Moreover, Liu and Yang (2018), in their research on the sharing economy, showed that the PEOU is the strongest determinant of perceived usefulness and attitudes toward new technologies by users.

The consequences of the perception of ease of use with respect to user attitude formation have been significant, especially in systems necessitating user interaction with novel interfaces. PEOU, as pointed out by Ma and Liu (2005), is very important for users of web-based systems when the interface in question is not well known. This is particularly critical for

users of VR technology who must participate in new and unfamiliar immersive environments. Users' positive attitude formation is enhanced toward the VR system with easier and more intuitive systems.

Based on this extensive empirical evidence supporting the dual influence of PEOU, we propose the following:

H1: Perceived ease of use positively influences the perceived usefulness of VR for preserving straw weaving.

H2: Perceived ease of use positively influences attitudes toward using VR for straw weaving preservation.

2.3. Cultural heritage authenticity

The authenticity of VR contextualizes cultural heritage in how users regard the virtual representation and portrayal of their crafts as authentic and credible. In the case of the preservation of straw weaving, authenticity is the portrayal of skills, cultural aspects, and crafts within the virtual environment. While perceived usefulness focuses on functional performance improvements, cultural heritage authenticity represents a distinct dimension concerning how accurately virtual environments represent traditional practices' essence. Authenticity encompasses not only the physical representation of tools and techniques but also the preservation of tacit knowledge, cultural contexts, and historical significance that give straw weaving its unique identity. Unlike usefulness, which is performance-oriented, authenticity is concerned with cultural fidelity and the spiritual connection to heritage.

Various studies have shown the important role that authenticity plays in heritage preservation and its virtual interactions. Park et al. (2019) identified authenticity as the most important element of heritage tourism, noting that it is critical for users' engagement and experience. Authenticity in the case of VR environments is highly important because it affects users' perceptions of the technology, which is a crucial aspect of the environment.

In the most recent studies, the links between perceived authenticity and attitude change in the context of virtual heritage environments were noted as a focus. Sinha et al. (2024) noted that authenticity stands out as the most important element of attitudes toward the use of VR in heritage depictions compared with other elements such as cost and the enjoyment of using technology. This finding has great implications for the maintenance of cultural authenticity during VR-based craft preservation because it will make users more favorable and accept the use of technology.

The aspect of authenticity in digital heritage is multilayered. Li et al. (2024) reported that VR dimensions, such as interactivity and vividness, greatly affect one's perception of authenticity and presence in virtual environments, which also guides one's perceptions of the technology. In craft preservation, this is especially important because the accurate portrayal of complex skills and cultural procedures cultivates favorable dispositions towards the instructional system.

In addition, Pescarin et al. (2023) argued that both virtual and hybrid experiences employ strategies of authenticity that are constructionist and existentialist in nature. Such positions are also held by Vichnevetskaia (2021), who argues about the multifaceted nature of authenticity in the digital world and its influences on people's perceptions and participation. For the study of crafts through technology, these claims can be applied to suggest that preserving the authenticity of virtual environments may result in favorable attitudes toward technology and improved learning outcomes.

Based on this framework, together with existing evidence on the impact of authenticity on the experience of virtual heritage, we make the following suggestions:

H4: Cultural heritage authenticity positively influences attitudes toward the use of VR for the preservation of straw weaving.

2.4. User engagement and attitude formation

New studies have shown the role that engagement plays in influencing users' impressions of a VR-based learning environment. A study by Allcoat and von Mühlenen (2018) revealed that, compared with traditional teaching methods, VR learning environments not only boosted content mastery but also enhanced positive emotions, engagement, and overall sentiment toward the technology. Therefore, it can be concluded that highly engaged learners have a favorable impression of the VR-based craft preservation learning system.

According to Xin (2022), many VR environments stimulate users' emotional and cognitive engagement, which influences their feelings toward technology. As a contribution to literature, engagement is defined as the mediating variable in the relationship between attitude and VR technology and, thereby, is crucial in eliciting attitude change.

Some studies have recently highlighted additional components of engagement within VR learning environments. Li et al. (2022a) suggested that social and behavioral engagement are strong predictors of emotional engagement, which then causes attitude change. This has direct implications for craft preservation, where sociocultural domains predominantly shape the users' attitudes towards the learning process.

The extent of participation and the disposition formed within the VR ecosystem, on the other hand, is contingent upon the caliber of experiences offered. Lee et al. (2020) noted that users' attitudes, both qualitatively and systematically, were more favorable due to heightened engagement and telepresence.

This was supported by Makransky and Lilleholt (2018), who demonstrated that immersive, emotionally and cognitively engaging VR technology

profoundly increases people's attitudes toward using the technology positively.

In their exhaustive meta-analysis on the topic, Yu and Xu (2022) reported that educational VR users demonstrated an affirmative attitude in every instance, with engagement being the dominant internal mediating variable. In addition, Lin et al. (2024) reported that VR improves all aspects of engagement—cognitive, behavioral and effective and thus is crucial in developing positive attitudes toward technology.

With this considerable amount of evidence, we posit that there is a positive relationship between variables:

H5: User engagement positively influences attitudes toward the use of VR for straw weaving preservation.

2.5. Attitudes and behavioral intentions

The relationship between attitudes and behavioral intentions is known in the context of the acceptance of new technologies. Several meta-analyses have confirmed the relationship between positive attitudes toward technologies and their intended use, at least within the areas of virtual and augmented reality for cultural heritage purposes (Abdullah and Ward, 2016; Bakı et al., 2018).

Studies concentrating on cultural heritage have more recently highlighted attitudes as autonomous determinants of behavioral intent. The positive attitudes of visitors toward the application of VR/AR technologies at heritage sites can be associated with their intentions to apply these technologies (Wen et al., 2023). Kang et al. (2023) demonstrated that educators' attitudes toward digital technologies for teaching intangible cultural heritage profoundly influence their intent to use these technologies.

A user's attitude will remain a mediator in any relationship between the different influences and the behavioral intentions in the case of adopting cultural heritage technology. As in the case of Li et al. (2022b), attitude as a mediator has been highlighted through the user's perceptions of using cultural heritage technology and their actions towards using it. Such mediators enhance the comprehension of other factors, such as perceived usefulness, perceived ease of use, and the involvement of a user, which all guide behavioral intentions.

Based on this substantial theoretical and empirical evidence supporting the relationship between attitudes and behavioral intentions, we propose the following:

H6: Attitude positively influences the behavioral intention to use VR for learning traditional straw weaving crafts.

3. Methodology

To evaluate user acceptance of VR technology for the preservation of traditional straw weaving, this investigation employs a mixed-methods approach. The research design consists of a primary quantitative phase informed by the TAM framework, followed by a qualitative phase that aims to provide a deeper understanding of the unexpected findings. This is a sequential explanatory design where we first test hypothesized relationships and afterwards examine the reasons behind these relationships through qualitative inquiry.

In the primary quantitative phase, user perception data on the ease of use of the VR straw weaving tutorial was gathered using a cross-sectional survey. Attitudes and behavioral intention data were also collected with user engagement and cultural heritage authenticity. This is consistent with established practices in technology acceptance research, including those related to cultural heritage sites (Wen et al., 2023; Kang et al., 2023). Concerning implementation, respondents were shown a straw-weaving VR tutorial composed of videos, screenshots, and diagrams. This was followed by a closed-ended survey measuring their perceptions and attitudes toward the tutorial. This primary phase provided evidence for all six proposed relationships within the research model while controlling for prior experiences with VR and knowledge of traditional crafts as confounding factors.

In consideration of the quantitative analysis, a subsequent qualitative stage was carried out with a subset of participants to gain deeper insight into the reasoning behind certain statistical outcomes, especially the lack of significant relationships between some constructs. This illustrative sequential design employing mixed methodologies enables a fuller comprehension of the acceptance of VR technology in the preservation of cultural heritage than what could be provided by any single approach.

The process of data collection was carried out in two stages. In the quantitative phase, we conducted a survey that incorporated videos, screenshots, and diagrams of VR straw-weaving projects. This allowed respondents to conceptualize instructional VR systems for straw-weaving, devoid of hands-on engagement with the systems. Verbally guided descriptions were provided outlining the systems for their components and characteristics prior to completing the survey. Recruitment was done through social media as well as mailing lists from universities and forums for culture and crafts as well as other relevant communities and similar groups.

In this study, the quantitative sample size was estimated using the power-matching technique outlined by Lakens (2022) alongside G*Power; this estimation is based on structural equation modelling as well as effect size, power, and model complexity (Andrade, 2020; Adhikari, 2021). Data collection took place over a four-week period, with frequent proactive adjustments during the period to achieve even demographic distribution. Some basic knowledge of VR or traditional crafts was required of respondents to answer the questions posed to them.

Out of 287 responses, which were above the criteria deduced from outlier and non-responder calculations, 287 responses were retained based on validity after applying Hair and Alamer's (2022) recommendation of 200 participants for structural equation modelling.

In the original sample, we purposively chose 15 participants to capture a variety of differing viewpoints and demographic attributes for the qualitative follow-up phase. Participants were selected based on their ability to attend interviews as well as their respective age, degree of technical familiarity, and experience with traditional crafts. The qualitative sample size was set according to information saturation. In this case, interviews were conducted until recurring themes surfaced with very few new ideas. This study employed both quantitative and qualitative methods for data collection. For the quantitative section of this study, a survey questionnaire was formulated based on multi-item scales, and responses were captured through a 5-point Likert scale where 1 denoted "strongly disagree" and 5 indicated "strongly agree."

As shown in Table 1, the measurement scales for five constructs were blended from different literature sources. PU and PEOU were taken from Tang et al. (2023), modified to focus on the application of VR technology concerning straw weaving preservation. Cultural heritage authenticity was adapted from Farrelly et al. (2020) and Su (2018), who assessed appreciation for the traditional straw weaving VR representation's authenticity. The scale measures users' perceptions of the authenticity of the virtual environment (knowledge, culture, and physical embodiment) of straw weaving. User engagement was taken from Doherty and Doherty (2018); O'Brien and Toms (2008) analyzed VR-based straw weaving user engagement through cognitive and behavioral participation. The scale measures the degree of immersion and participation users experience when interacting with the virtual system.

Attitude was changed based on Dwivedi et al. (2019) and Kim et al. (2009), who assessed users' evaluative VR technology focused on straw weaving preservation. This scale captures comprehensive beliefs and sentiments concerning the application of VR in the context of craft preservation.

Behavioral intentions incorporated elements from Warshaw and Davis (1985) and Netemeyer and Bearden (1992), who measured users' intentions to adopt VR for learning traditional straw weaving crafts. This scale assesses the future and the likelihood of using technology for craft learning.

Table 1: Measurement items

Construct	Code	Items	Reference
Perceived usefulness (PU)	PU1	Using VR technology would enhance my effectiveness in preserving traditional straw weaving crafts.	Tang et al. (2023)
	PU2	VR technology would be useful for documenting and transferring straw weaving knowledge.	
	PU3	Using VR technology would improve the learning experience of traditional straw weaving techniques.	
Perceived ease of use (PEOU)	PEOU1	Learning to use VR technology for straw weaving preservation would be easy.	Tang et al. (2023)
	PEOU2	Interacting with the VR straw weaving system would be clear and understandable.	
	PEOU3	It would be easy to become skilled at using VR technology for straw weaving preservation.	
Cultural heritage authenticity (CHA)	CHA1	The VR environment accurately represents the physical aspects of traditional straw weaving tools and techniques.	Farrelly et al. (2020) and Su (2018)
	CHA2	The VR experience preserves the cultural context and historical significance of straw weaving crafts.	
	CHA3	The VR representation maintains the integrity and authenticity of traditional straw weaving knowledge.	
User engagement (UE)	UE1	I would become fully immersed in the VR straw weaving experience.	Doherty and Doherty (2018) and O'Brien and Toms (2008)
	UE2	Learning traditional straw weaving techniques through VR would hold my attention.	
	UE3	The VR experience would stimulate my curiosity about traditional straw weaving crafts.	
Attitude (ATT)	ATT1	Using VR technology for learning straw weaving crafts would be a good idea.	Dwivedi et al. (2019) and Kim et al. (2009)
	ATT2	I would have a positive attitude toward using VR technology for preserving traditional straw weaving techniques.	
	ATT3	I believe using VR technology for straw weaving preservation would be beneficial.	
Behavioral intention (BI)	BI1	I intend to use VR technology to learn straw weaving techniques when it becomes available.	Warshaw and Davis (1985) and Netemeyer and Bearden (1992)
	BI2	I plan to use VR technology for straw weaving preservation in the future.	
	BI3	I expect that I would use VR technology for learning traditional straw weaving skills.	

For the qualitative phase, a semi-structured interview guide was developed to explore participants' reasoning behind their survey responses, particularly focusing on the relationship between ease of use and usefulness, and how they conceptualized authenticity in relation to other constructs. The interview guide contained open-ended questions such as "How do you determine whether a VR system would be useful for learning straw weaving?" and "What role does authenticity play in your assessment of a VR system's value for craft preservation?" Interviews were conducted either in person or via video conferencing, lasting approximately 20-30 minutes each, and were audio-recorded with participants' consent. Our study employed a sequential mixed-methods analysis approach. For the quantitative phase, this study was conducted via SmartPLS 4 software to carry out PLS–SEM analysis.

The use of PLS-SEM was due to its appropriateness for technology acceptance phenomena and its ability to address complex and comprehensive predictive models (Hair and Alamer, 2022). The first step of the analysis was preliminary data screening to check for missing values, outliers, and respondent answer patterns.

A measurement model was evaluated in two steps. In the first step, we measured the reliability of the constructs via internal consistency indicators, namely, Cronbach's alpha and composite reliability. Both values were above the acceptable threshold of 0.7. In the second step, validity was assessed through convergent validity (average variance extracted values examined were above the threshold of 0.5) and discriminant validity (the Fornell–Larcker criterion and Heterotrait–Monotrait ratio cut-off value of 0.85 were employed).

For structural model evaluation, path coefficients were tested via the bootstrapping technique with 5000 resamples to calculate t and p values. The model's predictive power was measured with the R^2 value, and the effect sizes (f^2) were calculated to examine the influence of the exogenous constructs on the endogenous constructs.

For the qualitative phase, interview recordings were transcribed verbatim and analyzed using thematic analysis following Braun and Clarke's (2006) six-step approach. This process involved: (1) familiarization with the data through repeated reading, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. Two researchers independently coded the data to enhance reliability, with disagreements resolved through discussion. The resulting themes were used to interpret and contextualize the quantitative findings, particularly focusing on explaining unexpected relationships identified in the structural model. This integration of quantitative and qualitative findings provided a more comprehensive understanding of VR acceptance for straw weaving preservation.

The qualitative phase was designed to complement the quantitative findings by exploring participants' reasoning and providing context for unexpected statistical results. Following preliminary analysis of the quantitative data, we identified key areas requiring deeper exploration: (1) the non-significant relationship between perceived ease of use and perceived usefulness, (2) the non-significant impact of cultural heritage authenticity on attitudes, and (3) the high HTMT values suggesting construct overlap.

Interviews were conducted with 15 participants selected from the original sample based on their survey responses and demographic characteristics to ensure diverse perspectives. The semi-structured interviews explored how participants conceptualized and distinguished between different constructs, particularly usefulness and authenticity in the context of VR-based craft preservation. Participants were encouraged to elaborate on how they evaluated VR systems for straw weaving and what factors they considered most important.

Qualitative data were analyzed using thematic analysis to identify recurring patterns. Three main themes emerged: (1) content fidelity prioritization over interface simplicity, (2) integration of authenticity within usefulness assessments rather than as separate considerations, and (3) context-specific technology evaluation criteria for cultural heritage applications. These themes provided valuable insights for interpreting the quantitative findings and developing a more nuanced understanding of technology acceptance in cultural heritage contexts.

4. Results

The study attracted a diverse sample of participants interested in the intersection of VR technology and traditional straw weaving crafts. Among the 366 total respondents, 202 (55.2%) were male and 164 (44.8%) were female, indicating a relatively balanced gender distribution. The participants ranged in age from 18--65 years, with a mean age of 34.2 years (SD = 9.7). Most participants (63.4%) were between 25 and 45 years old, reflecting a predominantly working-age demographic. In terms of educational background, 42.6% had completed undergraduate studies, 31.2% held postgraduate degrees, and the remaining 26.2% had a high school education or below. With respect to prior experience, 58.3% of the participants reported having some familiarity with VR technology, whereas only 27.8% indicated previous exposure to traditional straw weaving crafts. This disparity highlights the greater prevalence of technological experience than traditional craft knowledge among the sample population, which aligns with the broader context of declining traditional craft engagement mentioned in the paper's introduction.

Table 2 presents the reliability and validity indicators for all the constructs in the research model.

All the constructs demonstrated excellent internal consistency reliability, with Cronbach's alpha values ranging from 0.846--0.966, which are well above the recommended threshold of 0.7 (Hair and Alamer, 2022). Similarly, the composite reliability measures (both rho_a and rho_c) exceeded 0.85 for all the constructs, further confirming their reliability. Convergent validity was established through the average variance extracted (AVE) values, which ranged from 0.764–0.937, substantially above the minimum acceptable threshold of 0.5. This finding indicates that each construct explains more than 76% of the variance in its respective indicators, providing strong evidence of convergent validity. The particularly high AVE values for Attitude (0.920) and Behavioral Intention (0.937) suggest that these constructs are especially well represented by their measurement items.

Table 3 presents the Heterotrait–Monotrait ratio (HTMT) values for all the construct pairs in the research model. Most of the HTMT values fell below the conservative threshold of 0.85, indicating good discriminator validity between most construct pairs. However, the HTMT value between perceived_usefulness and cultural_heritage_ authenticity (1.079) exceeded the recommended

threshold, suggesting a potential discriminant validity issue between these two constructs. Additionally, the HTMT value between user_engagement and perceived_ease_of_use (0.967) was slightly above the threshold, indicating that these constructions may share some conceptual overlap.

Table 2: Construct reliability and validity overview

Construct	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE
Attitude	0.956	0.957	0.972	0.920
Behavioral_intention	0.966	0.967	0.978	0.937
Cultural_heritage_authenticity	0.846	0.851	0.907	0.764
Perceived ease_of use	0.915	0.916	0.946	0.854
Perceived_usefulness	0.890	0.893	0.932	0.820
User_engagement	0.915	0.916	0.946	0.855

Table 3: Heterotrait–monotrait ratio (HTMT) analysis

Construct relationships	Heterotrait-Monotrait ratio (HTMT)
Behavioral_intention <-> attitude	0.800
Cultural_heritage_authenticity <-> attitude	0.513
Cultural_heritage_authenticity <-> behavioral_intention	0.355
Perceived Ease_of Use <-> attitude	0.659
Perceived Ease_of Use <-> behavioral_intention	0.677
Perceived Ease_of Use <-> cultural_heritage_authenticity	0.059
Perceived_usefulness <-> attitude	0.491
Perceived_usefulness <-> behavioral_intention	0.353
Perceived_usefulness <-> cultural_heritage_authenticity	1.079
Perceived_Usefulness <-> perceived ease_of use	0.064
User_engagement <-> attitude	0.576
User_engagement <-> behavioral_intention	0.584
User_engagement <-> cultural_heritage_authenticity	0.060
User_Engagement <-> perceived ease_of use	0.967
User_engagement <-> perceived_usefulness	0.055

Table 4 indicates that three of the six hypothesized relationships were statistically significant. H2, positing that perceived ease of use positively influences attitude, was strongly supported ($\beta = 0.699$, $t = 12.609$, $p < 0.001$), suggesting that users' perceptions of how easy VR technology is to use have a substantial effect on their attitudes toward using VR for straw weaving preservation. H3, which proposes that perceived usefulness positively influences attitudes, was also supported ($\beta = 0.320$, $t = 2.911$, $p = 0.004$), indicating that users' beliefs about the utility of VR technology in preserving straw weaving techniques significantly affect their attitudes. H6, suggesting that Attitude positively influences Behavioral Intention, received the strongest support ($\beta = 0.769$, $t = 34.809$, $p < 0.001$), confirming that users' attitudes toward VR technology are a powerful predictor of their intentions to use it for learning traditional straw weaving crafts. In contrast, H1, which proposed that perceived ease of use positively influences perceived usefulness, was not supported ($\beta = -0.025$, $t = 0.475$, $p = 0.635$). This unexpected finding contradicts traditional TAM relationships and suggests that in the context of VR-based craft preservation, users' perceptions of ease of use may not necessarily enhance their perceptions of usefulness. Similarly, H4 ($\beta = 0.163$, $t = 1.508$, $p = 0.132$) and H5 ($\beta = -0.083$, $t = 1.396$, $p = 0.163$), which proposed positive relationships between cultural heritage authenticity and user engagement with attitudes, respectively, were not supported. Interestingly, User Engagement showed a slight negative coefficient, contrary to the hypothesized positive relationship, although this effect was not statistically significant.

The model explained 59.1% of the variance in Attitude ($R^2 = 0.591$) and 59.2% of the variance in Behavioral Intention ($R^2 = 0.592$), indicating moderate to strong explanatory power. These findings suggest that while the core TAM relationships between perceived usefulness, attitudes, and behavioral intentions remain robust in the context of VR-based straw weaving preservation, the extended constructs of cultural heritage authenticity and user engagement may play more complex roles than initially hypothesized.

Table 4: Path coefficients and significance levels

Hypothesis	Relationship	Original sample	Sample mean	SD	t-statistics	p-values
H1	Perceived_ease_of_use -> Perceived_usefulness	-0.025	-0.025	0.054	0.475	0.635
H2	Perceived_ease_of_use -> attitude	0.699	0.696	0.055	12.609	0.000
H3	Perceived_usefulness -> attitude	0.320	0.312	0.110	2.911	0.004
H4	Cultural_heritage_authenticity -> attitude	0.163	0.172	0.108	1.508	0.132
H5	User_engagement -> attitude	-0.083	-0.078	0.059	1.396	0.163
H6	Attitude -> behavioral_intention	0.769	0.769	0.022	34.809	0.000

As shown in Table 5, the R-squared values indicate that the model explains a substantial proportion of the variance in both Attitude (60.8%) and Behavioral Intention (59.1%), suggesting good predictive power for these key constructs. The high adjusted R-squared values (60.4% for Attitude and 59.0% for Behavioral Intention) confirm that the explained variance remains robust even when accounting for the number of predictors in the model. However, the negligible R-squared for

perceived usefulness (0.1%, with a negative adjusted value) indicates that perceived ease of use alone fails to explain meaningful variance in perceived usefulness in this context, contradicting traditional technology acceptance model assumptions.

Table 5: R-squared values

Construct	R-squared	R-squared adjusted
Attitude	0.608	0.604
Behavioral_intention	0.591	0.590
Perceived_usefulness	0.001	-0.002

Following the quantitative analysis, we conducted follow-up interviews with fifteen participants to explore the reasoning behind unexpected statistical relationships. Semi-structured interviews focused on participants' conceptualization of key constructs and their interrelationships in the context of VR technology for straw weaving preservation. Thematic analysis of the interview data revealed three primary themes with several subthemes as presented in Table 6. These themes provide context for understanding the non-significant relationship between perceived ease of use and perceived usefulness, the high HTMT values between cultural heritage authenticity and perceived usefulness constructs, and why traditional TAM relationships may not fully apply in cultural heritage preservation contexts.

5. Discussion

This study investigated the preservation of traditional straw weaving crafts through the acceptance of virtual reality technology by integrating the factors of cultural heritage into the TAM. Our results both validate key TAM relationships and reveal important contextual differences in heritage technology acceptance.

The relationship between attitudes and behavioral intentions is strong ($\beta = 0.769$, $p < 0.001$), which confirms the core TAM relationship's predictive power alongside other technology uses in heritage research (Wen et al., 2023; Kang et al., 2023). Attitude was indeed affected by perceived usefulness, but its modest impact indicates that perceived usefulness is not the primary driver in this context ($\beta = 0.320$, $p = 0.004$).

Table 6: Qualitative themes from follow-up interviews

Theme	Subthemes	Representative quotes	Implications for quantitative findings
Content fidelity over interface simplicity	Prioritization of accurate representation Technical complexity tolerance Craft essence preservation	"The system has to get the techniques right first. I'm willing to deal with a complicated interface if it shows me exactly how the traditional methods work." "I don't care how easy it is to use it if it doesn't capture the essence of the craft. The technical complexity is secondary to having accurate, detailed representations of the weaving techniques."	Explains the non-significant relationship between perceived ease of use and perceived usefulness (H1). Users prioritize content quality over interface simplicity in cultural heritage contexts.
Authenticity embedded within usefulness assessment	Inseparable evaluation Authenticity as a prerequisite for usefulness Integrated assessment process	"When I think about how useful a VR system would be for learning straw weaving, I'm automatically including how authentic it is. If it's not authentic, it's simply not useful for preservation purposes." "Usefulness and authenticity are the same thing to me in this context. I can't separate them, but an inauthentic system would be useless for preserving traditional knowledge."	Explains the high HTMT values between cultural heritage authenticity and perceived usefulness. Indicates these constructions are not conceptually distinct for users. Also explains why authenticity did not have a significant direct effect on attitudes (H4).
Context-specific technology evaluation criteria	Distinctive evaluation standards Purpose-driven assessment Cultural value considerations	"I evaluate technology differently depending on what it's for. For preserving traditional crafts, I care about different things than I would for, say, a gaming system." "The criteria I use to judge VR for cultural preservation are completely different from what I'd use for entertainment or business applications. Preserving our heritage requires different standards."	Provides a broader framework for understanding why traditional technology acceptance models may not apply in cultural heritage contexts. Suggests the need for domain-specific evaluation models.

Perceived ease of use emerged as the strongest predictor of attitude formation ($\beta = 0.699$, $p < 0.001$), which supports Wang and Goh's (2017) research claiming that PEOU is particularly important for interfaces to which users are not accustomed. This indicates that stakeholders need to lessen the technical hurdles associated with VR so that it can be embraced in craft preservation.

In contrast to conventional TAM expectations, PEOU does not have a significant effect on perceived usefulness, contradicting other studies (Abdullah et al., 2016; Verma and Sinha, 2018). Our qualitative follow-up suggests users judge systems' usefulness based on knowledge transmission quality rather than interface simplicity.

Neither the authenticity of cultural heritage user engagement nor user participation greatly influences attitudes, which contradicts the findings of prior studies (Park et al., 2019; Allcoat and von Mühlenen, 2018). High HTMT values indicate an overlap between these constructs, suggesting that concerns over authenticity are perhaps included within evaluations of usefulness instead of being independent predictors. The non-significant relationship between perceived ease of use and perceived usefulness represents an important departure from traditional TAM relationships and warrants deeper consideration. This finding suggests that in the context of cultural heritage preservation, the functional utility of VR technology may be evaluated through different mechanisms than in more conventional technology contexts. While business applications typically show that easier systems are perceived as more useful, heritage preservation involves complex value judgments about cultural transmission that may override usability considerations. Our follow-up qualitative interviews provided valuable context for

understanding the unexpected non-significant relationship between perceived ease of use and perceived usefulness. Several participants explained that they evaluated a VR system's usefulness primarily based on its content quality rather than interface simplicity. As one interviewee stated, "I don't care how easy it is to use it if it doesn't capture the essence of the craft. The technical complexity is secondary to having accurate, detailed representations of the weaving techniques."

The qualitative data also illuminated why cultural heritage authenticity did not significantly impact attitudes directly. Interviewees consistently described authenticity as being embedded within their assessment of usefulness rather than as a separate consideration. One participant noted: "When I think about how useful a VR system would be for learning straw weaving; I'm automatically including how authentic it is. If it's not authentic, it's simply not useful for preservation purposes." This helps explain the high HTMT values between these constructions and suggests that users conceptually integrate authenticity within usefulness rather than treating them as separate factors.

These findings have important implications for both theory and practice. From a theoretical perspective, our results challenge the universality of standard TAM relationships in specialized contexts like cultural heritage preservation. The integration of authenticity within usefulness assessments suggests that users may employ domain-specific evaluation frameworks that merge functional and cultural considerations. This indicates a need for specialized technology acceptance models for cultural applications that explicitly account for these unique evaluation patterns.

For VR developers and cultural preservation stakeholders, these insights suggest prioritizing content fidelity and authentic representation over interface simplicity. While ease of use remains important for attitude formation, the development process should focus first on accurate representation of traditional techniques through close collaboration with master crafters. The integration of authenticity and usefulness in users' evaluations means that development efforts should not treat these as separate design considerations but as interconnected aspects of the same user need: authentic knowledge transmission.

Limitations include a cross-sectional design and the possibility of interconstruct overlap. A notable limitation of this study is that participants evaluated VR technology based on videos, screenshots, and verbal descriptions rather than through direct interaction with an actual VR system. This approach, while practical for obtaining a larger sample size, may have affected participants' ability to accurately assess constructs like perceived ease of use and user engagement, which are experiential in nature. Further studies should analyze time changes in refining the measurement tools, as well as the connections between acceptance factors and learning outcomes through qualitative methods, to highlight what our quantitative work missed. Future research should incorporate hands-on VR experiences to measure these constructions more reliably, potentially revealing different relationship patterns than those observed in this study.

6. Conclusion

This study investigated the acceptance of VR technology in preserving traditional straw weaving crafts by extending the technology acceptance model with cultural heritage-specific factors and employing a mixed-methods approach. Our quantitative findings confirm the importance of core TAM relationships, particularly the strong influence of perceived ease of use on attitude formation and the robust link between attitudes and behavioral intentions. However, the unexpected nonsignificant relationships between perceived ease of use and perceived usefulness, as well as the limited direct impact of cultural heritage authenticity and user engagement, reveal unique dynamics of technology acceptance in cultural heritage contexts.

Our follow-up qualitative investigation provided valuable insights into these unexpected findings, revealing that users conceptualize usefulness and authenticity as intertwined rather than separate constructs in heritage contexts. Participants consistently prioritized content fidelity over interface simplicity and applied specialized evaluation criteria specific to cultural preservation contexts.

List of abbreviations

ATT	Attitude
AVE	Average variance extracted
BI	Behavioral intention
CHA	Cultural heritage authenticity
HTMT	Heterotrait–Monotrait ratio
PEOU	Perceived ease of use
PLS-SEM	Partial least squares structural equation modelling
PU	Perceived usefulness
SD	Standard deviation
TAM	Technology acceptance model
UE	User engagement
VR	Virtual reality

Compliance with ethical standards

Ethical considerations

All participants provided informed consent prior to their participation in the study, and their responses were collected anonymously to ensure confidentiality.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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