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Relationships of Tangibles and AR Content Quality with Heritage Conservation Intention at AR-Enhanced Archaeological Heritage Sites: The Mediating Roles of Experiential Authenticity and Place Attachment

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Abstract

Cultural heritage preservation is essential to sustainable development, yet fragmentary remains at archaeological sites limit visitors' understanding of their significance. Augmented reality (AR) can enrich heritage interpretation and visitor experience. However, the psychological pathways linking visitors' evaluations of the physical environment and AR content to heritage conservation intention remain insufficiently understood. Based on stimulus–organism–response theory, Tangibles and AR content quality are modeled as external stimuli in this study, with experiential authenticity and place attachment as mediators and heritage conservation intention as the outcome. Survey data from 635 visitors who used the Mojiaoshan Pilgrimage Route AR Experience at Liangzhu Ancient City Ruins Park were analyzed using partial least squares structural equation modeling (PLS-SEM). Tangibles and AR content quality were positively associated with experiential authenticity. In the baseline model, Tangibles also showed a weak direct association with place attachment, whereas AR content quality showed no significant direct association with attachment and was related to it mainly through experiential authenticity. Both stimuli showed significant indirect associations with heritage conservation intention through experiential authenticity and place attachment, consistent with the proposed theoretical pathway. Place attachment showed a stronger direct association with heritage conservation intention than experiential authenticity. The hypothesized moderating effect of Tangibles on the relationship between AR content quality and experiential authenticity was nonsignificant. These findings highlight the positive associations of both physical and digital quality evaluations with experiential authenticity, underscoring the roles of experiential authenticity and place attachment in understanding heritage conservation intention. The findings also inform site maintenance and AR content design; whether these associations translate into actual conservation behavior remains to be validated.

Keywords: archaeological heritage site; sustainable heritage tourism; AR content quality; experiential authenticity; place attachment; heritage conservation intention

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1. Introduction

The protection and sustainable use of cultural heritage are central to global sustainable development. The United Nations 2030 Agenda for Sustainable Development explicitly

calls for strengthening of efforts to protect the world's cultural and natural heritage under Sustainable Development Goal 11, Target 11.4 [1]. Archaeological heritage sites, which primarily consist of physical remains such as ancient city sites, palace foundations, tombs, and water management facilities, provide crucial material evidence for understanding the social structures and civilizational development of specific historical periods [2,3]. However, such sites are often incompletely preserved, and their original spatial configurations are difficult to discern, preventing visitors from grasping their historical significance from the existing remains alone [4,5]. Because these sites are open to the public, increasing visitor activity may also place pressure on the heritage sites themselves and their surrounding environments [6,7]. Enhancing visitors' understanding and experience while encouraging positive attitudes and behaviors toward heritage preservation is, therefore, a central challenge for the sustainable use of archaeological sites.

As digital technologies develop, cultural heritage presentation is evolving from static information delivery toward more immersive and interactive experiences [8,9]. Among these, augmented reality (AR) can overlay and integrate digital content with the site environment, presenting architectural and historical scenes that have been damaged, lost, or are otherwise difficult to observe directly, thereby helping visitors understand the site and its historical context [10–12]. In recent years, China has continued to advance the digital transformation of cultural heritage and has encouraged the application of AR and virtual reality in cultural and tourism contexts [13]. However, whether AR can effectively enhance the heritage experience still depends on the content's relevance to the site and on the clarity, accuracy, and comprehensibility of the information [14,15]. For heritage sites that are incompletely preserved and whose original appearance is difficult to discern, AR is of significant practical value.

During AR-enhanced site visits, visitors engage simultaneously with the physical environment and digital content. The physical environment constitutes the material foundation that visitors can directly perceive [16], while AR content supplements historical information missing from, or difficult to observe directly in, the existing ruins [14,17]. When these two sources of information jointly support immersion in historical contexts, they may enhance experiential authenticity [18]. Authenticity, in turn, may foster visitors' identification with and emotional connection to a place, producing place attachment [19]. Stronger place attachment is typically associated with more positive intentions toward heritage conservation and environmental responsibility [20,21].

However, research on cultural heritage has largely focused on service quality, state of preservation, and the physical environment [16], while research on AR tourism has focused on interactivity, technology acceptance, and experiential outcomes [14,22]. Few studies have incorporated both the physical environment and digital content into a single framework. Prior work using the stimulus–organism–response (S–O–R) framework has examined conservation intentions among visitors to World Heritage sites, primarily focusing on external stimuli such as outstanding universal value and service quality, mostly at natural heritage sites [7,23,24]. Building on this foundation, in this study, prior research is extended by (1) examining the direct and indirect associations of Tangibles and AR content quality with experiential authenticity and place attachment, (2) investigating how these psychological states link the two sources of perceived quality to heritage conservation intention, and (3) testing whether perceived Tangibles strengthen the positive relationship between AR content quality and experiential authenticity in archaeological heritage settings where fragmentary remains can make historical interpretation difficult.

Given the lack of a unified framework that jointly models the physical environment and AR content at incompletely preserved sites, this study examines how two external stimuli—Tangibles and AR content quality—are associated with visitors' experiential authenticity,

place attachment, and heritage conservation intention. Experiential authenticity is examined as an overall construct reflecting visitors' subjective experiences of authenticity [18], rather than through separate measures of object-based, constructive, and existential authenticity. Based on S–O–R theory, experiential authenticity and place attachment are specified as mediators and the theoretically proposed indirect path through experiential authenticity and then place attachment is tested. This ordering represents a theoretical specification rather than an established temporal sequence. The moderating role of perceived Tangibles in the relationship between AR content quality and experiential authenticity is also examined in this study. A central focus is whether the quality of the physical environment and AR content quality show similar or different patterns of association with place attachment and how experiential authenticity helps account for these patterns.

By distinguishing the direct and indirect associations of Tangibles and AR content quality with place attachment, the aim of this study was to clarify how evaluations of physical and digital aspects of heritage visits relate to visitors' psychological connections with a site. How these associations extend to heritage conservation intention among visitors who have used AR is examined further. The findings of this study are intended to provide insight into site maintenance, heritage interpretation, and AR content design, with implications focused on conservation-related intentions rather than demonstrated changes in conservation behavior.

2. Theoretical Background and Hypothesis Development

2.1. S–O–R Theory in AR-Enhanced Archaeological Heritage Tourism

The S–O–R theory posits that external stimuli trigger internal cognitive and emotional responses in individuals, which, in turn, influence their behavioral tendencies [25]. Accordingly, this study considers Tangibles and AR content quality as the two external stimuli (S) that visitors encounter at AR-enhanced archaeological heritage sites, reflecting the quality of the physical environment and of digital content, respectively. Experiential authenticity and place attachment are treated as visitors' internal psychological states (O). The proposed ordering of these constructs is theoretically motivated: experiential authenticity may strengthen visitors' emotional connections to the site and foster place attachment [26]. This ordering represents a theoretical specification rather than an established temporal sequence. Heritage conservation intention serves as the final behavioral response (R). The following subsections define these five constructs.

2.2. Tangibles in AR-Enhanced Archaeological Heritage Sites

Tangibles were originally defined in terms of the physical facilities, equipment, and other Tangible cues that customers can directly see and perceive [27]; this concept was subsequently adapted to the context of cultural heritage [16]. On the HISTOQUAL scale developed by Frochot and Hughes [16], Tangibles primarily reflect visitors' evaluations of the heritage site and its surrounding environment, including heritage preservation and maintenance, environmental cleanliness, site attractiveness, signage, and visible heritage elements. Recent research indicates that Tangibles remain an important quality dimension in cultural heritage and digitally enhanced visitor experiences. For example, they can significantly influence visitor loyalty and enhance perceived value in AR-assisted visits [28,29]. Accordingly, this study defines Tangibles as visitors' overall evaluation of physical environment quality at AR-enhanced archaeological heritage sites, primarily encompassing the preservation and maintenance of the remains, environmental cleanliness, site attractiveness, clarity of signage, and heritage elements visible on site.

Physical features, such as historic architectural forms and building materials, can help visitors perceive the historical characteristics of a place and strengthen their connection

to local history and culture [30]. Prior research links the preservation of on-site remains to visitors' experiential authenticity [31]. When digitally reconstructed AR content aligns spatially and historically with the physical remains and their surroundings, visitors are more likely to connect digital information with the physical site and form a more coherent and authentic experience [32]. Therefore, a well-maintained physical environment may enhance visitors' experiential authenticity [30,31].

Accordingly, the following hypothesis is proposed:

H1a. *Tangibles have a significant positive effect on visitors' experiential authenticity.*

Tangibles may also influence the psychological connection between visitors and heritage sites. Previous studies have found that visitors' positive evaluations of the historical environment, landscape attractiveness, and physical setting help strengthen their place attachment [33,34]. Related studies have also indicated that visitors' positive perceptions of the destination environment are an important antecedent of place attachment [35]. Well-preserved remains, attractive surroundings, and clearly visible heritage elements can help visitors recognize a site's historical and cultural value and appreciate its uniqueness. Therefore, visitors who evaluate a heritage site's physical environment more positively are more likely to identify with the site and develop a psychological connection to it.

Accordingly, the following is proposed:

H1b. *Tangibles have a significant positive effect on visitors' place attachment.*

2.3. AR Content Quality in AR-Enhanced Archaeological Heritage Sites

Information quality primarily reflects users' evaluations of the information a system provides, including its relevance, accuracy, completeness, and comprehensibility [17,36]. The concept has been applied to AR tourism contexts to evaluate AR content quality [14]. In this study, AR content quality is defined as visitors' subjective evaluations of the relevance, clarity, comprehensibility, and presentation appropriateness of the historical and cultural information provided through AR at archaeological heritage sites. This operational definition focuses on perceived content and presentation quality and does not directly assess the historical accuracy of digital reconstructions. Consequently, higher AR content quality ratings should not be interpreted as evidence that the reconstructed content conforms to archaeological evidence.

Some historic structures at archaeological heritage sites have disappeared or survive only partially, leaving visitors with limited physical evidence of past settings [5]. By overlaying digitally reconstructed content, AR can provide historical information absent from the physical site and help visitors connect the existing remains with their original forms and historical contexts [5,37]. Prior research indicates that closer alignment between AR content and the specific heritage context—in authenticity (faithful representations of exhibits and sites in their original forms) and educational value—can enhance visitors' satisfaction with AR use and their emotional experiences [15]. Therefore, when AR content is highly relevant to the site and presents clear, comprehensible information, visitors can more easily connect the digital reconstruction with the on-site remains, thereby enhancing their experiential authenticity during the visit.

Accordingly, the following is proposed:

H2a. *AR content quality has a significant positive effect on visitors' experiential authenticity.*

Place attachment is typically built upon visitors' recognition of a place's significance and unique value [38,39]. At incompletely preserved sites, visitors may struggle to understand

the historical value of the place from the existing remains alone. Clear AR content that is relevant to the site can supplement historical information and, through digital reconstruction, help visitors understand the site's past form, function, and cultural context [14,40]. When visitors better understand the historical and cultural significance of a heritage site through AR, they may be more likely to regard the site as uniquely valuable. As this understanding deepens, their identification with and psychological connection to the heritage site may also strengthen [39]. Therefore, high-quality AR content may promote place attachment. This parallels findings in digital service contexts, where research on O2O food delivery platforms similarly links service quality to emotional responses and continued usage [41], providing an analogous basis for quality-related psychological responses more broadly.

Accordingly, the following is proposed:

H2b. *AR content quality has a significant positive effect on visitors' place attachment.*

2.4. Experiential Authenticity

Early research on authenticity primarily focused on tourism objects, historical relics, or cultural displays themselves; later work expanded to visitors' subjective experiences during tourism activities [42–44]. Experiences of authenticity do not depend entirely on the authenticity of tourism objects themselves; they also relate to visitors' personal feelings in specific activities and contexts [42]. In cultural heritage tourism, visitors' perceptions of authenticity also involve their understanding of the heritage's history and culture, their connection to the past, and their personal experiences during the visit [43]. Drawing on these perspectives, in this study, experiential authenticity is conceptualized as a visitor-centered subjective experience grounded in a perceived connection to the site's history and cultural meanings. Within this broader interpretation, feelings of inspiration and uniqueness are considered experiential expressions associated with the heritage encounter, rather than sufficient indicators of authenticity on their own. These feelings can also arise from general experiential appreciation; therefore, their inclusion requires the historical and cultural context captured by the other items to be considered.

Research indicates that experiential authenticity can promote place attachment. Visitors' experiences of authenticity can significantly enhance place attachment, including place identity and dependence [26]. Studies have shown that meaningful experiences of authenticity can strengthen visitors' emotional connections to traditional cultural sites [45]. Thus, visitors who perceive greater authenticity in their experience of a heritage site are more likely to understand and identify with that site's historical and cultural significance, attribute greater personal meaning to it, and develop stronger emotional connections and place attachment.

Accordingly, the following is proposed:

H3. *Experiential authenticity has a significant positive effect on visitors' place attachment.*

2.5. Place Attachment

Place attachment refers to the emotional and psychological bond between a person and a specific place [46,47]. Previous research has conceptualized it as comprising two dimensions [38]: place identity, an individual's emotional identification with a place and its personal significance, and place dependence, the extent to which the place meets that person's activity needs. In tourism research, positive and meaningful travel experiences can strengthen visitors' ties to destinations and shape satisfaction, revisit intention, and destination loyalty [39,48]. Beyond tourism, research on online fitness communities has shown associations between digitally mediated social interactions, emotional states,

and behavior [49]. In heritage settings, however, place attachment specifically concerns visitors' connections to a site, which may be strengthened through meaningful historical experiences [26]. In this study, place attachment is defined as the overall psychological connection that visitors develop with an archaeological heritage site during an AR-enhanced visit. This connection is primarily reflected in identification with the site, how well it meets their needs during the visit, the special significance the site holds for them, and its irreplaceability relative to other similar heritage sites. Place identity and dependence capture distinct but related aspects of the person–place bond [38]. This study focuses on visitors' overall psychological connection with the heritage site rather than the separate contributions of these dimensions. Accordingly, place attachment is analyzed as an overall construct, consistent with the study's theoretical focus and previous research [39]. This conceptual rationale does not, by itself, establish measurement unidimensionality, and the aggregate approach may obscure differences between identity- and dependence-related associations.

2.6. Heritage Conservation Intention

Behavioral intention refers to an individual's subjective inclination to perform a particular behavior and serves as an important antecedent of actual behavior [50]. In heritage tourism, visitors' willingness to comply with conservation regulations, care for the heritage environment, and participate in conservation activities has implications for the long-term preservation and sustainable use of cultural heritage [7]. Heritage conservation intention captures this willingness, including efforts to discourage or prevent damage to heritage sites [7]. Accordingly, heritage conservation intention is defined here as visitors' subjective intention to protect heritage, formed during visits to AR-enhanced archaeological heritage sites.

Experiential authenticity can shape visitors' evaluations of the visit and their behavioral intentions [43,51]. Visitors who feel a strong connection to the past and experience the visit as authentic are more likely to recognize the value and uniqueness of cultural heritage and become more concerned with its long-term preservation. Previous studies have found that visitors' perceived heritage authenticity can influence their subsequent behavioral intentions [52,53]. In AR heritage tourism, experiential authenticity can enhance visitors' willingness to support cultural heritage conservation [40] and is associated with visitors' environmentally responsible and sustainable behaviors [20,21]. Therefore, greater experiential authenticity may strengthen visitors' heritage conservation intention.

Accordingly, the following is proposed:

H4a. *Experiential authenticity has a significant positive effect on visitors' heritage conservation intention.*

Place attachment is an important predictor of visitors' environmentally responsible behavior [20,54]. Prior research indicates that it has a significant positive effect on pro-environmental behavior overall, especially among tourists [54]. In cultural heritage tourism, visitors' place attachment to heritage sites is linked to heritage conservation and sustainable use [20,55]. Therefore, visitors who identify more strongly with a heritage site and develop a deeper emotional connection to it may have greater willingness to care for the heritage environment and support heritage conservation [20,54].

Accordingly, the following is proposed:

H4b. *Place attachment has a significant positive effect on visitors' heritage conservation intention.*

2.7. Mediating Effects

In this study, Tangibles and AR content quality are the external stimuli visitors encounter on site, while experiential authenticity and place attachment are their internal psychological responses. According to S–O–R theory, external stimuli can influence behavioral responses through internal cognitive and emotional states [25].

First, Tangibles and AR content quality may influence visitors' place attachment through experiential authenticity. A physical environment and AR content that are both of high quality can help visitors understand the site's history and enhance their experiential authenticity. Greater experiential authenticity, in turn, may help visitors recognize the site's special significance and develop stronger identification with and attachment to it [26,43,45]. Therefore, experiential authenticity may mediate the relationship between these two stimuli and place attachment.

Accordingly, the following are proposed:

H5a. *Experiential authenticity mediates the relationship between Tangibles and visitors' place attachment.*

H5b. *Experiential authenticity mediates the relationship between AR content quality and visitors' place attachment.*

Second, experiential authenticity may also mediate the effects of these stimuli on visitors' heritage conservation intention. When the physical environment or AR content enhances visitors' experiential authenticity, they may place greater value on the site's historical and cultural significance and help develop a stronger intention to protect it [20,21,40]. Therefore, experiential authenticity may mediate the relationship between these two types of external stimuli and visitors' heritage conservation intention.

Accordingly, the following are proposed:

H6a. *Experiential authenticity mediates the relationship between Tangibles and visitors' heritage conservation intention.*

H6b. *Experiential authenticity mediates the relationship between AR content quality and visitors' heritage conservation intention.*

Place attachment may also link the two stimuli to heritage conservation intention. A high-quality physical environment and high-quality AR content can help visitors recognize a site's value and strengthen their psychological connection to it [14,38,39]. As this connection strengthens, visitors may become concerned with the protection and long-term preservation of heritage sites [20,54]. Therefore, place attachment may mediate the relationships of Tangibles and AR content quality with heritage conservation intention.

Accordingly, the following are proposed:

H7a. *Place attachment mediates the relationship between Tangibles and visitors' heritage conservation intention.*

H7b. *Place attachment mediates the relationship between AR content quality and visitors' heritage conservation intention.*

Finally, an indirect path is proposed, linking Tangibles and AR content quality to heritage conservation intention through experiential authenticity, then place attachment. This specification draws on theoretical arguments that experiential authenticity may strengthen visitors' connections to the heritage site and that place attachment may support conser-

vation intention [20,26,45]. The proposed ordering is theoretical; the analysis examines a correlational structure consistent with this ordering rather than establish a temporal psychological process.

Accordingly, the following are proposed:

H8a. *Experiential authenticity and place attachment sequentially mediate the relationship between Tangibles and visitors' heritage conservation intention.*

H8b. *Experiential authenticity and place attachment sequentially mediate the relationship between AR content quality and visitors' heritage conservation intention.*

2.8. Interaction Effect of Tangibles and AR Content Quality on Experiential Authenticity

Visitors' perceptions of the physical environment may shape how they relate AR content to the heritage site. Favorable evaluations of the site's maintenance, signage, and visible heritage elements may provide a supportive context for connecting digital reconstructions with physical references [30,56]. Prior research also suggests that aligned information cues can reinforce overall evaluations [57]. On this basis, a reinforcement mechanism is proposed in this study whereby perceived Tangibles strengthen the positive relationship between AR content quality and experiential authenticity.

The Mojiaoshan Pilgrimage Route AR Experience overlays digitally reconstructed content on the on-site remains and their spatial locations. This arrangement reflects AR's emphasis on spatial correspondence between virtual content and the physical environment [58]. Visitors who evaluate the physical setting more favorably may therefore find it easier to relate AR information to the site, strengthening the association between AR content quality and experiential authenticity. The moderating factor of visitors' perceived Tangibles was examined in this study, instead of conducting an objective assessment of the site's preservation state.

Accordingly, the following is proposed:

H9. *Perceived Tangibles positively moderate the relationship between AR content quality and experiential authenticity.*

3. Materials and Methods

3.1. Theoretical Model and Analytical Framework

With the increasing adoption of digital technologies in tourism, the S–O–R theory has been used to explain how digital stimuli, such as AR, influence visitors' behavioral responses through their internal experiences [59–61]. Drawing on this theory, this study treats Tangibles and AR content quality as physical environmental stimuli and digital content stimuli, respectively. Tangibles reflect visitors' evaluations of physical remains and the on-site physical environment, while AR content quality reflects visitors' evaluations of the quality of historical and cultural information provided through AR [14]. Studies have tended to focus on either the physical environment of heritage sites or visitors' experiences with AR; few have incorporated both stimuli in a single framework. Therefore, in this study, both were examined within the same model to assess their associations with visitors' psychological experiences and heritage conservation intention.

At the organism level, experiential authenticity and place attachment are considered the visitors' internal psychological states; the former reflects visitors' subjective judgment that the visit feels historically grounded, while the latter represents the psychological and emotional bond between visitors and the heritage site [38,42,43]. When physical remains

and AR content help visitors connect the present ruins to the site's history, visitors are more likely to experience authenticity, which may, in turn, strengthen their emotional connection to the site [26,45]. Therefore, this study positions experiential authenticity before place attachment to examine their proposed sequential relationship.

At the response level, this study treats heritage conservation intention as the behavioral response, primarily reflecting visitors' tendencies to comply with conservation regulations, care for the heritage environment, discourage destructive behavior, and participate in conservation activities [7,20]. Experiential authenticity may enhance visitors' recognition of heritage value, while place attachment may further encourage concern for the long-term preservation of heritage sites, thereby strengthening their heritage conservation intention [20,21,54].

Based on S–O–R theory, this paper specifies Tangibles (TAN) and AR content quality (ACQ) as stimuli, experiential authenticity (EA) and place attachment (PA) as internal psychological states, and heritage conservation intention (HCI) as the outcome. The EA → PA → HCI pathway represents a theoretically specified sequential indirect association rather than an established temporal psychological process. Given the cross-sectional survey design, the analysis examines whether the observed data support the theoretically proposed associations; it cannot establish temporal ordering or causality. The research model is shown in Figure 1.

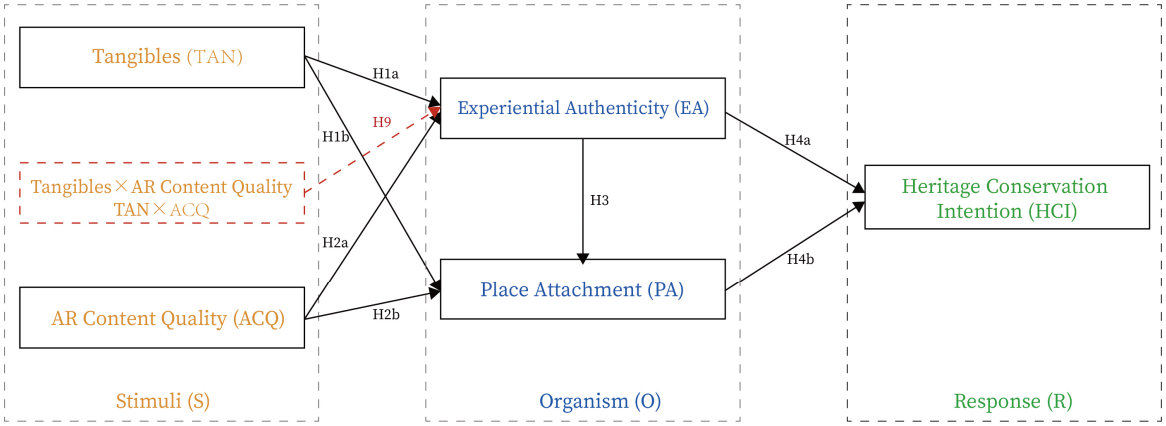


Figure 1. Conceptual model and hypothesized relationships.

3.2. Study Site

This study was conducted at the Liangzhu Ancient City Ruins Park in Hangzhou, Zhejiang Province, China. The Liangzhu Ancient City Site is a late Neolithic archaeological site in China, dating back approximately 5000 years, that was inscribed on the World Heritage List in 2019. It includes the ancient city, the palace complex, the peripheral water management system, and burial grounds [62]. This study focused on the Mojiaoshan site within the park. Figure 2 shows the study site at Mojiaoshan. Located in the core area of the ancient city, Mojiaoshan served as a principal palace area during the Liangzhu period. To help visitors understand archaeological remains that are incompletely preserved or difficult to recognize on site, the park launched the "Mojiaoshan Pilgrimage Route AR Experience" in the Mojiaoshan palace complex in 2023. Visitors can access the AR application on their mobile devices to view digitally reconstructed content—including palace architecture, pottery-making activities, scenes of daily life, and ritual activities—allowing digital historical reconstructions to appear alongside the physical remains [63].



Figure 2. Views of the Mojiaoshan site (photographs taken by the authors). Note. The Chinese-language text visible in the photographs is part of the original on-site signage. "莫角山" refers to "Mojiaoshan", and "朝圣之路" is labeled "Mojiaoshan Pilgrimage Road" on the sign.

3.3. Research Instruments and Measurement

Tangibles were measured using five items, drawn mainly from the HISTOQUAL scale developed by Frochot and Hughes [16]. Given that archaeological sites emphasize the preservation of remains more than architectural restoration, some items were adapted to this context. AR content quality was measured using four items adapted from an existing scale [14]. Experiential authenticity was measured using four items adapted from previous studies to suit the archaeological heritage site context [40,43]. Specifically, EA1–EA3 (historical connectedness, inspiration, and uniqueness) were adapted from the authenticity scale used by Han et al. [40] in AR-enhanced heritage tourism, while EA4 emphasizes visitors' perceptions of the site's historical and cultural narratives. EA2 and EA3 were retained to preserve the experiential emphasis of the source measure: they address inspiration arising from the site's landscape and overall impression and the perceived uniqueness of the experience at the site. Within the conceptualization outlined in Section 2.4, these items were intended to capture subjective responses accompanying visitors' engagement with heritage, alongside the more explicitly historical and cultural content of EA1 and EA4. The questionnaire underwent expert review for wording clarity and content validity before data collection (Section 3.4). However, neither prior use nor expert review eliminates the possibility that EA2 and EA3 also capture broader experiential appreciation. Their site-specific wording does not, by itself, make them specific to authenticity. Supplementary analyses therefore examined the items' internal structure and the sensitivity of the estimated associations to their inclusion, rather than establishing their content validity. Place attachment was measured using five items covering place identity and place dependence [38,39]. It was analyzed as an overall construct because this study focuses on visitors' overall psychological connection with the site. Supplementary analyses examined the empirical distinction between the two dimensions and the dimensional structure of the overall place attachment measure. Heritage conservation intention was measured using four items, primarily based on previous research [7,60], with some wording adapted to the archaeological site context. The specific measurement items and their sources for each construct are presented in Table 1.

Table 1. Measurement items and sources.

Construct	Items	Sources
Tangibles (TAN)	The physical remains at this archaeological heritage site were well preserved and maintained.	[16]
	The overall cleanliness and upkeep of this archaeological heritage site and its grounds were satisfactory	
	The physical setting of this site was attractive	
	The directional signs provided at this site were clear and helpful	
	This site offered interesting physical remains and visible heritage elements	
AR Content Quality (ACQ)	The historical and cultural content presented through the AR experience was relevant to this archaeological heritage site	[14]
	The historical and cultural content presented through the AR experience was easy to understand	
	The historical and cultural content presented through the AR experience was clear	
	This AR experience presented historical and cultural content in formats appropriate to the archaeological heritage site	
Experiential Authenticity (EA)	During the visit, I felt connected to the history of this archaeological heritage site	[40,43]
	The overall landscape and impression of this site inspired me	
	I had a unique experience at this site	
	During my visit to this site, I could sense the history and cultural narratives associated with the site	
Place Attachment (PA)	I feel that this archaeological heritage site is a part of me	[38,39]
	For me, this site is one of the best places to engage in the activities I enjoy	
	This site is very special to me	
	No other similar site can compare with this one	
	I am very attached to this site	
Heritage Conservation Intention (HCI)	I will abide by the management regulations of the archaeological heritage site I visited	[7,60]
	I am willing to take care of the physical remains and surrounding environment of this site	
	I will actively participate in various heritage protection activities	
	I am willing to discourage others from engaging in behaviors that may harm this site	

All measurement items were rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

3.4. Research Participants, Sampling, and Data Collection

The participants were Chinese visitors who had visited the Liangzhu Ancient City Ruins Park and had used the Mojiaoshan Pilgrimage Route AR Experience. Eligible participants were recruited through purposive sampling on Chinese tourism forums and social media. The questionnaire was administered on Wenjuanxing. All participants read the study information and informed consent form and proceeded only after consenting to participate.

Participants were required to be at least 18 years of age, to have visited the Liangzhu Ancient City Ruins Park within the past year, and to have used the on-site AR content, including the interpretation and digital reconstruction features for historical scenes. Additionally, the questionnaire included instructed-response attention checks to identify inattentive respondents. The survey ended automatically for respondents who failed to meet any eligibility criteria or pass the attention checks. Eligibility was assessed through self-reported visitation and on-site AR use, without independent verification of these experiences or objective assessment of AR engagement duration and depth. Sensitivity analyses using six- and three-month visitation windows were conducted to examine whether the principal associations changed when the recall window was shortened (Sections 3.5 and 4.10).

Five experts in relevant fields reviewed the initial questionnaire for wording clarity and content validity. Based on their feedback, minor revisions were made to the questionnaire. After obtaining approval from the Institutional Review Board of Jeonbuk National University on 3 September 2026 (Approval No. JBNU IRB 2026-07-012-003; initial approval on 22 July 2026; amendment approved on 3 September 2026), an online pilot study involving 35 eligible participants was conducted from 4 to 6 September 2026 to assess the survey's comprehensibility and preliminary reliability. Cronbach's alpha exceeded 0.75 for all constructs, and participants reported no difficulty understanding the questionnaire. The main survey was subsequently conducted from 9 to 20 September 2026.

The questionnaire was terminated automatically when screening responses indicated ineligibility, and these terminated questionnaires were not counted as completed submissions. A total of 678 completed questionnaires were collected: 204 through tourism forums, 397 through social media, and 77 through recruitment through the questionnaire platform. After excluding 43 questionnaires because of issues with response quality, 635 were retained for analysis, accounting for 93.7% of completed submissions. This percentage does not represent a survey response rate.

3.5. Data Analysis

Partial least squares structural equation modeling (PLS-SEM) analyses were conducted using SmartPLS 4. First, SPSS 27 was used to summarize the sample's demographic characteristics using descriptive statistics. Common method bias was assessed using Harman's single-factor test and a full collinearity assessment, using 3.30 as the reference threshold for the variance inflation factor (VIF) [64].

Second, the reliability and validity of the measurement model were evaluated. Indicator reliability was primarily assessed using the outer loadings of individual items, with 0.70 as the reference threshold. Internal consistency was evaluated using Cronbach's α and composite reliability (CR), with values of 0.70 or higher considered acceptable [65]. Convergent validity was assessed using average variance extracted (AVE), with 0.50 as the reference threshold [65,66]. Discriminant validity was assessed using the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT) [67,68]. Principal component analysis (PCA) was used to examine the dimensionality of the experiential authenticity and place attachment items. HTMT was used to assess the empirical distinction between the place identity and place dependence item groups.

Third, the structural model was evaluated using the inner model's VIF values, coefficients of determination (R^2), and effect sizes (f^2). Standardized path coefficients (β) were also reported [65,66]. Additionally, the standardized root mean square residual (SRMR) was used to provide a supplementary assessment of model fit. Hypotheses were tested using bootstrapping with 5000 resamples and two-tailed tests. Path coefficients, t-values, *p*-values, and 95% confidence intervals were reported to assess the hypothesized effects and their statistical significance [65]. Beyond direct effects, specific indirect effects were tested

through experiential authenticity and place attachment separately, as well as sequential indirect effects through both mediators.

Fourth, to test the interaction effect of Tangibles and AR content quality on experiential authenticity, a two-stage approach was used to generate the interaction term [69]. The effect size of the interaction term was assessed against Kenny's [70] benchmarks of 0.005, 0.010, and 0.025 for small, medium, and large effects, respectively. Furthermore, following an established procedure [71], simple slopes and conditional indirect effects were estimated at three levels of Tangibles—low (one SD below the mean), average (mean), and high (one SD above the mean)—and assessed using bootstrap confidence intervals. A supplementary equivalence analysis used standardized item-mean scores in a regression of experiential authenticity on Tangibles, AR content quality, and their interaction. Two one-sided tests (TOST) was performed to evaluate the difference in the ACQ–EA slopes between Tangibles levels one standard deviation below and above the mean. Equivalence bounds were ±0.10 standardized slope units, using ±0.20 for sensitivity analysis. These exploratory bounds were selected during revision rather than preregistered. Equivalence was assessed at $\alpha = 0.05$ using the corresponding 90% confidence interval.

The model's out-of-sample predictive performance was evaluated using PLSpredict with 10-fold cross-validation repeated 10 times [72]. Models were estimated on training data and evaluated on held-out observations. Indicator-level Q^2predict, root mean squared error (RMSE), and mean absolute error (MAE) values were reported, and PLS-SEM prediction errors were compared with those of a linear model benchmark using the same data partitions. The cross-validated predictive ability test (CVPAT) was additionally used to compare the PLS-SEM model with the indicator's average benchmark [73].

Supplementary robustness analyses were conducted. An alternative model added direct paths from Tangibles and AR content quality to heritage conservation intention, and its direct paths, specific indirect effects, and explained variance were compared with those of the baseline model. Path coefficients and specific indirect effects were also re-estimated under three experiential authenticity item specifications (EA1 and EA4 only; excluding EA2 and EA3) and among visitors reporting a visit within the preceding six or three months, using 5000 bootstrap resamples and 95% confidence intervals. Covariate-adjusted models included gender, age, education, occupation, and visit history (dummy-coded), with a reduced specification including age, education, and visit history only. First-time and repeat visitors were compared after assessing measurement invariance using the measurement invariance of composite models (MICOM) procedure, with path differences evaluated using 5000 permutations.

3.6. Ethics

This study was conducted in accordance with ethical requirements for research involving human participants. Before completing the survey, all respondents were informed of the study's purpose, participation procedures, the scope of data use, and their right to withdraw without penalty. They proceeded to the main questionnaire only after consenting. The survey did not collect directly identifying information, such as names or contact details. All data were stored in anonymous form and used only for research purposes. This study received ethical approval from the Institutional Review Board (IRB) of Jeonbuk National University (Approval No. JBNU IRB 2026-07-012-003; initial approval on 22 July 2026; amendment approved on 3 September 2026). The survey was conducted after IRB approval was obtained, and data were processed in accordance with the approved research protocol.

4. Results

4.1. Demographic Characteristics of Respondents

The final sample comprised 635 valid responses. Demographic characteristics are shown in Table 2. Women accounted for 52.9%, while men accounted for 47.1%, a roughly balanced gender distribution. Respondents aged 25–34 formed the largest age group (31.2%), followed by those aged 18–24 (23.9%) and 35–44 (22.7%). Those aged 45–54 and 55 or older accounted for 17.5% and 4.7%, respectively. The sample of this study was compared with a sample of 254 AR-glasses users surveyed at the Liangzhu Museum within the same Liangzhu cultural heritage context [15]. Gender distributions were similar (52.9% vs. 50.4% female), while the present sample was less concentrated among younger respondents (55.1% aged 18–34 vs. 69.7% aged 18–30). Differences in AR technology and recruitment prevent a formal representativeness check; Section 4.10 shows that the main conclusions are robust to demographic covariates including age and education.

Table 2. Respondent demographic characteristics (N = 635).

	Items	Frequency	Proportion
Gender	Male	299	47.1%
	Female	336	52.9%
Age (in years)	18–24	152	23.9%
	25–34	198	31.2%
	35–44	144	22.7%
	45–54	111	17.5%
	≥55	30	4.7%
Education	High school or below	67	10.6%
	College diploma	300	47.2%
	Bachelor's degree	182	28.7%
	Postgraduate or above	86	13.5%
Occupation	Student	125	19.7%
	Employed	323	50.9%
	Other	187	29.4%
Visit experience	First-time visitor	402	63.3%
	Repeat visitor	233	36.7%

Regarding educational attainment, respondents with a college diploma formed the largest group (47.2%), followed by those with a bachelor's degree (28.7%). Respondents with postgraduate qualifications and those with a high school education or below accounted for 13.5% and 10.6%, respectively. Regarding occupation, 50.9% were employed, 19.7% were students, and 29.4% were in other occupational categories. Regarding visit history, first-time visitors accounted for 63.3%, while 36.7% of respondents were repeat visitors. Overall, the sample included visitors of different genders, ages, educational levels, and visit histories, with first-time visitors constituting the majority.

4.2. Evaluation of the Measurement Model

In this study, the measurement model was evaluated in terms of four aspects: indicator reliability, internal consistency, convergent validity, and discriminant validity. Indicator reliability was assessed using outer loadings; internal consistency, using Cronbach's α and CR; and convergent validity, using AVE. In general, outer loadings, Cronbach's α, and CR should be 0.70 or higher, and AVE should exceed 0.50 [65].

Table 3 reports outer loadings of 0.705–0.892, all above the 0.70 benchmark, supporting indicator reliability. Internal consistency was also satisfactory: Cronbach's α was between 0.815 and 0.891, while CR was between 0.871 and 0.924. Both measures exceeded 0.70 for every construct [65]. Convergent validity was supported by AVE estimates of 0.576–0.753, all above 0.50 [65].

Table 3. Reliability and validity analysis.

Constructs	Item	Loadings	Cronbach's α	CR	AVE
TAN	TAN 1	0.705	0.819	0.873	0.580
	TAN 2	0.790			
	TAN 3	0.755			
	TAN 4	0.810			
	TAN 5	0.743			
ACQ	ACQ 1	0.887	0.890	0.924	0.751
	ACQ 2	0.827			
	ACQ 3	0.889			
	ACQ 4	0.863			
EA	EA 1	0.773	0.821	0.882	0.652
	EA 2	0.862			
	EA 3	0.782			
	EA 4	0.809			
PA	PA 1	0.732	0.815	0.871	0.576
	PA 2	0.771			
	PA 3	0.715			
	PA 4	0.815			
	PA 5	0.757			
HCI	HCI 1	0.892	0.891	0.924	0.753
	HCI 2	0.822			
	HCI 3	0.887			
	HCI 4	0.870			

4.3. Discriminant Validity Analysis

As shown in Table 4, the square roots of AVE for TAN, ACQ, EA, PA, and HCI were 0.762, 0.867, 0.807, 0.759, and 0.868, respectively. For each construct, the square root of AVE exceeded its correlations with all other constructs [67]. Therefore, the Fornell–Larcker criterion was satisfied, supporting the discriminant validity of the constructs.

Table 4. Discriminant validity (Fornell–Larcker criterion).

	TAN	ACQ	EA	PA	HCI
TAN	0.762				
ACQ	0.108	0.867			
EA	0.429	0.439	0.807		
PA	0.345	0.284	0.610	0.759	
HCI	0.297	0.201	0.475	0.689	0.868

The HTMT estimates in Table 5 span 0.122–0.805. PA and HCI yielded the largest estimate (0.805), which was still below the 0.85 cutoff [68]. Every construct pair therefore met this criterion, providing additional evidence of discriminant validity.

Table 5. Discriminant validity (HTMT).

	TAN	ACQ	EA	PA	HCI
TAN					
ACQ	0.122				
EA	0.521	0.513			
PA	0.418	0.330	0.740		
HCI	0.346	0.226	0.550	0.805	

As a further check for discriminant validity, 95% confidence intervals were obtained for each pairwise HTMT estimate from 5000 bootstrap resamples [68,74]. Table 6 reports these intervals, all of which exclude 1. The results thus meet the HTMT inference criterion [68] and reinforce the evidence that the constructs are distinct.

Table 6. HTMT bootstrap confidence intervals.

Relationship	HTMT	95% CI (Percentile)	95% CI (Bias-Corrected)
TAN ↔ ACQ	0.122	[0.035, 0.206]	[0.032, 0.205]
TAN ↔ EA	0.521	[0.447, 0.592]	[0.448, 0.592]
TAN ↔ PA	0.418	[0.331, 0.502]	[0.330, 0.501]
TAN ↔ HCI	0.346	[0.259, 0.429]	[0.261, 0.432]
ACQ ↔ EA	0.513	[0.442, 0.577]	[0.441, 0.577]
ACQ ↔ PA	0.330	[0.247, 0.410]	[0.244, 0.408]
ACQ ↔ HCI	0.226	[0.144, 0.307]	[0.143, 0.306]
EA ↔ PA	0.740	[0.683, 0.793]	[0.681, 0.791]
EA ↔ HCI	0.550	[0.481, 0.614]	[0.480, 0.614]
PA ↔ HCI	0.805	[0.761, 0.846]	[0.759, 0.845]

To further examine the dimensional structure of place attachment (PA), supplementary analyses were conducted. The HTMT value between the place identity items (PA1, PA3, and PA5) and place dependence items (PA2 and PA4) was 1.003, indicating limited empirical distinction between the two dimensions in this sample. Principal component analysis of the five PA items yielded a first eigenvalue of 2.880, explaining 57.6% of the total variance. These findings are consistent with retaining PA as an overall construct, although they do not establish the conceptual equivalence of its two dimensions.

For experiential authenticity (EA), principal component analysis of the four items yielded a first eigenvalue of 2.608, explaining 65.2% of the total variance. This result indicates a dominant common component among the items but does not establish their content validity. In particular, shared variance cannot determine whether inspiration and uniqueness reflect experiential authenticity or broader positive evaluations of the heritage experience.

4.4. Assessment of Common Method Bias and Collinearity

To assess potential common method bias, Harman's single-factor test and a full collinearity assessment were conducted [64]. First, all 22 measurement items were entered into an unrotated principal component analysis for Harman's single-factor test. The first principal component explained 34.018% of the total variance, below the commonly used 50% reference threshold. Second, following the full collinearity assessment approach proposed by Kock [64], latent variable scores from the baseline model were used to regress each construct on all remaining constructs in turn and calculate the corresponding VIF values. The VIF values for TAN, ACQ, EA, PA, and HCI were approximately 1.260, 1.253, 2.019, 2.380, and 1.928, respectively, all below the reference threshold of 3.30. These diagnostic results did not indicate serious common method bias.

Before assessing the structural model, this study used VIF values to assess collinearity among the predictor constructs. As shown in Table 7, the VIF values associated with the structural paths ranged from 1.012 to 1.593, all below the reference threshold of 3.30. The highest VIF values were observed for EA → HCI and PA → HCI, both at 1.593. These results indicate no substantial collinearity concerns, supporting further assessment of the structural model.

Table 7. VIF values of the inner model.

Relationship	VIF
TAN → EA	1.012
TAN → PA	1.238
ACQ → EA	1.012
ACQ → PA	1.251
EA → PA	1.516
EA → HCI	1.593
PA → HCI	1.593

4.5. Explanatory Power of the Structural Model and Effect Sizes

As shown in Table 8, the model explained 34.0%, 38.1%, and 47.9% of the variance in experiential authenticity (EA), place attachment (PA), and heritage conservation intention (HCI), respectively. Heritage conservation intention had the highest R^2, followed by place attachment and experiential authenticity. Overall, the R^2 values for all endogenous constructs were within an acceptable range, suggesting that the model had reasonable explanatory power [65].

Table 8. Coefficients of determination (R^2).

Construct	R^2	Adjusted R^2
EA (Experiential Authenticity)	0.340	0.338
PA (Place Attachment)	0.381	0.378
HCI (Heritage Conservation Intention)	0.479	0.477

As shown in Table 9, effect sizes varied across the structural paths. The PA → HCI path had the largest effect size ($f^2 = 0.486$), indicating a large effect. The EA → PA path had an effect size of 0.324, indicating a medium effect. The ACQ → EA ($f^2 = 0.237$) and TAN → EA ($f^2 = 0.223$) paths also exhibited medium effects. In contrast, the effect sizes for TAN → PA ($f^2 = 0.014$), ACQ → PA ($f^2 = 0.001$), and EA → HCI ($f^2 = 0.009$) were all below the threshold of 0.02 for a small effect [65,75].

Table 9. Effect sizes (f^2).

Relationship	f^2
TAN → EA	0.223
TAN → PA	0.014
ACQ → EA	0.237
ACQ → PA	0.001
EA → PA	0.324
EA → HCI	0.009
PA → HCI	0.486

These results indicate that place attachment contributed substantially to heritage conservation intention. Tangibles and AR content quality both exhibited medium effects on

experiential authenticity, with AR content quality showing a slightly larger effect. In contrast, the direct effect of AR content quality on place attachment was very small, consistent with the nonsignificant ACQ → PA path.

4.6. Evaluation of Model Fit and Predictive Performance

As shown in Table 10, the SRMR value of the estimated model was 0.049, below the reference threshold of 0.08, suggesting a satisfactory model fit [76,77].

Table 10. Model fit indices.

Index	Saturated Model	Estimated Model
SRMR	0.048	0.049
d_ULS	0.586	0.602
d_G	0.196	0.197
Chi-square	727.105	728.896
NFI	0.895	0.895

As shown in Table 11, PLSpredict yielded positive Q^2predict values for all 13 endogenous indicators [72]. Compared with the linear model (LM) benchmark, PLS-SEM yielded lower RMSE values for all indicators and lower MAE values for 12 indicators, while PA5 showed equal MAE values at the reported three-decimal precision. For HCI, both error measures were lower across all four indicators, with RMSE reductions of approximately 0.6–1.0% relative to LM based on the reported values. Overall, these results demonstrate a consistent predictive advantage over the LM benchmark in terms of RMSE. However, the modest improvements for HCI, together with its construct-level Q^2predict of 0.111, suggest that its practical predictive usefulness remains limited.

Table 11. Indicator-level out-of-sample predictive performance (PLSpredict).

Indicator	Q^2Predict	PLS-SEM RMSE	PLS-SEM MAE	LM RMSE	LM MAE
EA1	0.185	1.068	0.881	1.075	0.885
EA2	0.254	1.108	0.908	1.120	0.916
EA3	0.213	1.012	0.833	1.021	0.841
EA4	0.214	0.984	0.807	0.990	0.814
PA1	0.068	1.136	0.932	1.143	0.938
PA2	0.085	1.155	0.966	1.164	0.976
PA3	0.097	1.111	0.932	1.122	0.938
PA4	0.124	1.062	0.889	1.068	0.895
PA5	0.123	1.134	0.938	1.140	0.938
HCI1	0.092	1.178	0.990	1.185	0.997
HCI2	0.084	1.138	0.948	1.145	0.953
HCI3	0.074	1.076	0.902	1.087	0.909
HCI4	0.086	1.159	0.982	1.170	0.986

Note: LM = linear model; RMSE = root mean squared error; MAE = mean absolute error.

CVPAT provided a further comparison of predictive performance against the indicator average (IA) benchmark [73]. In Table 12, the average loss differences were −0.305 for EA, −0.138 for PA, and −0.119 for HCI, with $p < 0.001$ in all three cases. Across constructs, the average difference was −0.184 ($t = 7.435$, $p < 0.001$). These consistently negative and significant differences show that the PLS-SEM model produced a lower prediction error than the IA benchmark.

Table 12. CVPAT results.

Construct	PLS Loss	IA Loss	Average Loss Difference	t	*p*
EA	1.090	1.395	−0.305	8.152	<0.001
PA	1.255	1.393	−0.138	5.317	<0.001
HCI	1.296	1.415	−0.119	4.560	<0.001
Overall	1.217	1.401	−0.184	7.435	<0.001

4.7. Hypothesis Testing: Direct Effect Analysis

In this study, bootstrapping was used with 5000 resamples to test the direct effects among the variables; the results are presented in Table 13. TAN was positively associated with EA ($\beta = 0.386$, $p < 0.001$) and PA ($\beta = 0.105$, $p = 0.003$), supporting H1a and H1b statistically. However, the TAN → PA effect size was below the small-effect threshold of 0.02 ($f^2 = 0.014$), indicating limited practical importance.

Table 13. Direct effects.

Hypotheses	Relationship	β	t	*p*	Decision
H1a	TAN → EA	0.386 ***	12.625	<0.001	Supported
H1b	TAN → PA	0.105 **	2.963	0.003	Supported
H2a	ACQ → EA	0.398 ***	13.155	<0.001	Supported
H2b	ACQ → PA	0.031 ns	0.853	0.393	Not Supported
H3	EA → PA	0.551 ***	15.724	<0.001	Supported
H4a	EA → HCI	0.087 *	2.350	0.019	Supported [a]
H4b	PA → HCI	0.635 ***	19.370	<0.001	Supported

Note: β = standardized path coefficient. Statistical significance was assessed using bootstrapping with 5000 resamples [65]. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns = nonsignificant. [a] H4a received statistical support, but its effect size was practically negligible under the adopted benchmark ($f^2 = 0.009$), and this association was not robust to the alternative model specification reported in Section 4.10 (Table A5).

ACQ was significantly and positively associated with EA ($\beta = 0.398$, $p < 0.001$), supporting H2a; however, its association with PA was not statistically significant ($\beta = 0.031$, $p = 0.393$), and thus, H2b was not supported.

EA was positively associated with PA ($\beta = 0.551$, $p < 0.001$), supporting H3. PA was strongly associated with HCI ($\beta = 0.635$, $p < 0.001$, $f^2 = 0.486$), supporting H4b. The EA → HCI association was statistically significant ($\beta = 0.087$, $p = 0.019$) but practically negligible ($f^2 = 0.009$). Thus, all direct-effect hypotheses except H2b received statistical support in the baseline model, although H4a had limited practical importance and was sensitive to model specification (Section 4.10, Table A5).

4.8. Hypothesis Testing: Analysis of Mediating Effects

Bootstrapping was further used to test specific indirect effects; the results are presented in Table 14. The indirect effect of TAN on PA through EA was significant ($\beta = 0.213$, $p < 0.001$), and the corresponding indirect effect of ACQ on PA through EA was also significant ($\beta = 0.219$, $p < 0.001$); therefore, both H5a and H5b were supported.

The specific indirect effects of TAN and ACQ on HCI through EA were statistically significant but small in magnitude ($\beta = 0.034$, $p = 0.024$; $\beta = 0.035$, $p = 0.021$, respectively). Thus, H6a and H6b received statistical support in the baseline model, although their practical importance should not be overstated. Both indirect associations were sensitive to model specification, with their confidence intervals including zero in the alternative model (Section 4.10, Table A5). The indirect effect of TAN on HCI through PA was significant

(β = 0.067, p = 0.004), supporting H7a; however, the indirect effect along the ACQ → PA → HCI path was not statistically significant (β = 0.020, p = 0.396), and thus, H7b was not supported.

Table 14. Specific indirect effects.

Hypothesis	Relationship	β	t	p	Decision
H5a	TAN → EA → PA	0.213 ***	9.564	<0.001	Supported
H5b	ACQ → EA → PA	0.219 ***	10.038	<0.001	Supported
H6a	TAN → EA → HCI	0.034 *	2.254	0.024	Supported [a]
H6b	ACQ → EA → HCI	0.035 *	2.315	0.021	Supported [a]
H7a	TAN → PA → HCI	0.067 **	2.896	0.004	Supported
H7b	ACQ → PA → HCI	0.020 ns	0.849	0.396	Not Supported
H8a	TAN → EA → PA → HCI	0.135 ***	8.564	<0.001	Supported
H8b	ACQ → EA → PA → HCI	0.139 ***	8.770	<0.001	Supported

Note: β = standardized indirect effect. Indirect effects were assessed using bootstrapping with 5000 resamples. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns = nonsignificant. [a] H6a and H6b received statistical support in the baseline model, but these associations were sensitive to the alternative model specification reported in Section 4.10 (Table A5).

The specific indirect effects along TAN → EA → PA → HCI (β = 0.135, $p < 0.001$) and ACQ → EA → PA → HCI (β = 0.139, $p < 0.001$) were statistically significant, supporting H8a and H8b within the theoretically specified model. These findings are consistent with the proposed indirect association structure but do not establish temporal ordering or causality.

Supplementary PLS-SEM analyses compared the theoretically specified ordering with reversed and parallel mediation models (Appendix A, Table A1). The specified EA → PA → HCI indirect effects were significant for both TAN and ACQ (β = 0.135 and 0.139, respectively), but the reversed PA → EA → HCI effects were also significant (β = 0.012 and 0.010). All parallel indirect effects had 95% confidence intervals excluding zero. The smaller coefficients for the reversed path indicate a weaker specific association in that direction rather than evidence against its statistical plausibility; because the EA → PA → HCI and PA → EA → HCI specifications are not nested, the comparison relies on the near-identical explained variance in HCI across models rather than on the relative magnitude of individual path coefficients. The explained variance in HCI was nearly identical across the original, reversed, and parallel models (R^2 = 0.479, 0.479, and 0.480, respectively). These results do not establish the temporal ordering of EA and PA. The proposed ordering is therefore retained as a theoretically informed correlational structure rather than an empirically established temporal sequence.

4.9. Interaction Effects and Conditional Indirect Effects

To test H9, a two-stage approach was used to generate the TAN × ACQ interaction term between Tangibles (TAN) and AR content quality (ACQ), and it was included in the structural model to examine its effect on experiential authenticity (EA) [69]. The results are presented in Table 15.

Table 15. Moderating effect of Tangibles.

Path	β	STDEV	t	p	95% CI	f^2	Decision
TAN × ACQ → EA	−0.026	0.030	0.852	0.394	[−0.084, 0.033]	0.001	Not Supported

The effect of TAN × ACQ on EA was not statistically significant (β = −0.026, STDEV = 0.030, t = 0.852, p = 0.394, 95% CI = [−0.084, 0.033]); therefore, H9 was not

supported. The effect size of the interaction term, $f^2 = 0.001$, was below the established small-effect threshold of 0.005 [70], indicating a minimal contribution to the model's explanatory power. After the interaction term was included, the R^2 for EA increased only slightly from 0.3403 to 0.3409 ($\Delta R^2 = 0.0006$), and the model's explanatory power remained virtually unchanged. TAN did not significantly moderate the relationship between ACQ and EA.

Figure 3 shows the simple slopes of AR content quality on experiential authenticity at three levels of Tangibles: low (−1 SD), average (mean), and high (+1 SD). All three slopes were positive and statistically significant (low TAN: $\beta = 0.423$, 95% CI = [0.333, 0.509], $p < 0.001$; average TAN: $\beta = 0.398$, 95% CI = [0.340, 0.455], $p < 0.001$; high TAN: $\beta = 0.372$, 95% CI = [0.294, 0.446], $p < 0.001$). The estimated slopes differed only slightly across the three levels, appearing as nearly parallel lines in Figure 3. This pattern was consistent with the nonsignificant interaction effect.

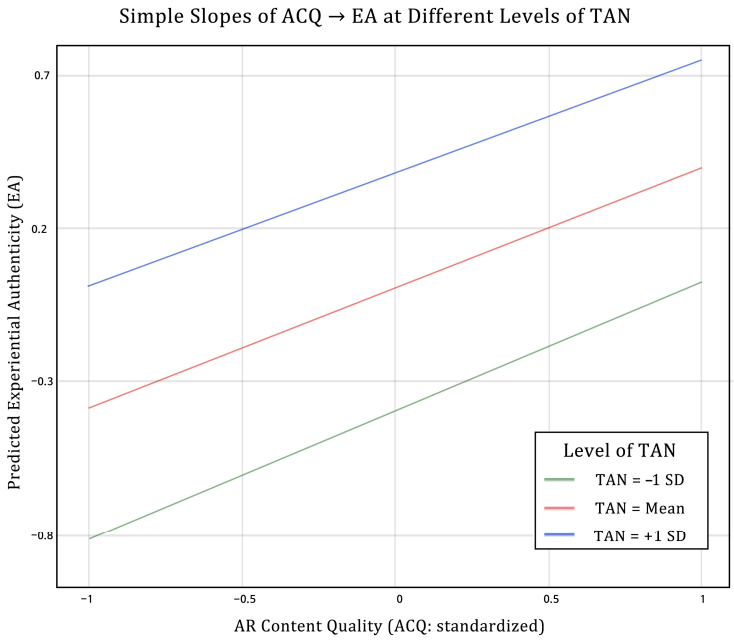


Figure 3. Simple slope analysis of the moderating effect of Tangibles on the relationship between AR content quality and experiential authenticity.

Although the interaction effect itself was not statistically significant, conditional indirect effects were further estimated along the two paths, ACQ → EA → HCI and ACQ → EA → PA → HCI, at low, average, and high levels of TAN [71]. The results are presented in Table 16 to provide a more comprehensive description of these indirect effects across levels of Tangibles.

Table 16. Conditional indirect effects at different levels of Tangibles.

Indirect Path	TAN Level	Effect	95% CI	*p*
ACQ → EA → HCI	−1 SD	0.037	[0.005, 0.070]	0.025
	Mean	0.035	[0.005, 0.064]	0.021
	+1 SD	0.032	[0.005, 0.061]	0.023
ACQ → EA → PA → HCI	−1 SD	0.148	[0.110, 0.192]	<0.001
	Mean	0.139	[0.110, 0.172]	<0.001
	+1 SD	0.130	[0.098, 0.165]	<0.001

As shown in Table 16, for both the ACQ → EA → HCI and ACQ → EA → PA → HCI paths, the 95% bootstrap confidence intervals for the conditional indirect effects excluded zero at low (−1 SD), average (mean), and high (+1 SD) levels of TAN. The point estimates of the indirect effects for both paths decreased slightly as TAN levels increased, but this pattern alone did not provide evidence of moderated mediation.

The indices of moderated mediation for the two paths were −0.002 (95% CI = [−0.009, 0.003]) and −0.009 (95% CI = [−0.030, 0.012]), respectively. Both confidence intervals included zero, indicating that moderated mediation was not statistically supported for either path. Together with the interaction term results in Table 15, these findings indicate that H9 is not supported. Tangibles did not significantly moderate the relationship between AR content quality and experiential authenticity. These nonsignificant results should not be interpreted as proof that the proposed moderating effect does not exist.

Supplementary TOST analyses based on standardized item-mean scores were carried out to assess the difference in the ACQ–EA slopes at high (+1 SD) versus low (−1 SD) levels of perceived Tangibles (high minus low). The estimated difference was −0.055, with a 90% confidence interval of [−0.164, 0.054]. Equivalence was not established within the stricter bounds of ±0.10 standardized slope units ($p = 0.249$), although it was established within the wider sensitivity bounds of ±0.20 ($p = 0.014$). These exploratory bounds were selected during revision. Thus, the nonsignificant interaction does not establish that the slope difference is negligible under the stricter criterion. Detailed results are reported in Appendix A, Table A2.

4.10. Robustness and Sensitivity Analyses

Table A3 in Appendix A compares the baseline model with two covariate-adjusted specifications. The directions and statistical significance of all reported direct and specific indirect associations remained unchanged. The largest absolute coefficient change from the baseline was 0.021, and differences between the two adjusted models did not exceed 0.003. The TAN → PA and EA → HCI associations remained small, while ACQ → PA and ACQ → PA → HCI remained nonsignificant.

Before conducting the visit-history multigroup analysis, measurement invariance was assessed using the MICOM procedure. Configural invariance was established by applying identical measurement specifications and estimation settings across groups. As shown in Table 17, compositional invariance was supported for all five constructs ($p = 0.111$–0.964). Equality of composite means and variances was established for TAN, EA, PA, and HCI, whereas ACQ exhibited a significant difference in composite means ($p = 0.028$). Thus, partial measurement invariance was established across all constructs, providing a basis for comparing structural path coefficients between first-time and repeat visitors.

Table 17. MICOM results.

Construct	Configural Invariance	Compositional Invariance *p*	Equal Means *p*	Equal Variances *p*	Conclusion
TAN	Established	0.329	0.148	0.912	Full invariance
ACQ	Established	0.524	0.028	0.977	Partial invariance
EA	Established	0.349	0.183	0.397	Full invariance
PA	Established	0.964	0.793	0.242	Full invariance
HCI	Established	0.111	0.304	0.676	Full invariance

Note: $p > 0.05$ indicates invariance; full invariance requires three MICOM steps, whereas partial invariance requires Steps 1 and 2.

Comparisons between first-time visitors ($n = 402$) and repeat visitors ($n = 233$) revealed no statistically significant between-group differences in the seven direct paths or the two sequential indirect associations (Appendix A, Table A4). Permutation p-values ranged from 0.221 to 0.721 for the direct paths and were 0.216 and 0.863 for the sequential indirect associations. These findings provide no evidence of differences in the examined associations by visit history.

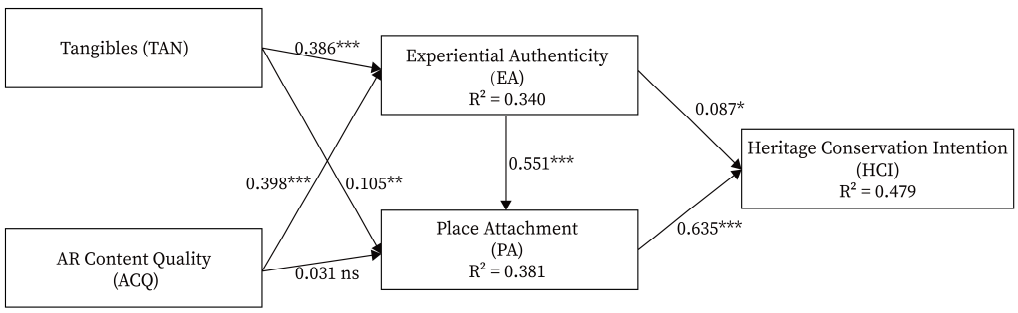
An alternative model added direct paths from TAN and ACQ to HCI (Appendix A, Table A5). Neither additional path was statistically significant, and HCI's R^2 increased only slightly, from 0.479 to 0.481. The sequential indirect associations through EA and PA remained significant. In the alternative model, however, the EA → HCI association and the specific indirect associations through EA alone had confidence intervals that included zero, indicating that these smaller associations were sensitive to model specification. This sensitivity suggests that the statistical support for H4a, H6a, and H6b should be interpreted cautiously rather than as robust evidence of direct or EA-specific indirect effects.

Sensitivity analyses examined three alternative EA specifications: retaining EA1 and EA4 only and excluding EA2 and EA3 (Appendix A, Table A6). The sequential indirect coefficients remained positive and statistically significant (all $p < 0.001$) across these specifications, ranging from 0.098 to 0.124 for TAN and from 0.107 to 0.127 for ACQ. However, ACQ → PA became significant in the two-item specification, whereas EA → HCI was non-significant when EA2 was excluded. Thus, the broader indirect pattern was stable, but some individual associations depended on the EA item specification. These checks do not resolve the construct's content-validity limitations.

Restricting the sample to visitors who had visited within six months ($n = 593$) or three months ($n = 489$) preserved the directions and significance patterns of the direct and specific indirect associations (Appendix A, Table A7). The largest absolute change in a direct coefficient relative to the full sample was 0.025. Both sequential indirect associations remained positive, with confidence intervals excluding zero. These findings indicate stability across shorter recall windows but do not rule out recall bias.

4.11. Summary of Research Findings

Figure 4 summarizes the baseline structural model and its standardized path coefficients. The interaction effect is reported separately in Table 15, with the simple slopes illustrated in Figure 3. Overall, the results were consistent with the external stimulus–internal psychological state–behavioral response logic of S–O–R theory: both Tangibles and AR content quality showed indirect associations with heritage conservation intention through experiential authenticity and place attachment. These associations are discussed in Section 5.



Note: Path coefficients are standardized beta values.
*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns = non-significant.

Figure 4. Baseline structural model and standardized path coefficients.

5. Discussion

The results are generally consistent with the basic logic of S–O–R theory, which posits that external stimuli influence behavioral responses through internal psychological states [25]. The following discussion examines the direct and indirect associations of Tangibles and AR content quality with experiential authenticity, place attachment, and heritage conservation intention.

Tangibles mainly supply material and spatial cues that visitors can directly perceive. At Mojiaoshan, well-preserved physical remains, such as palace terraces, together with environmental maintenance and clear signage, can help visitors form judgments of authenticity. This is consistent with previous findings on heritage environments [16,30,31,54]. AR content, by contrast, provides historical information that existing remains cannot directly convey. The Mojiaoshan Pilgrimage Route AR Experience lets visitors connect the site with past activities through digital reconstructions of buildings, daily life, and ritual scenes, thereby supporting a deeper understanding of the site [78,79]. Therefore, at fragmented archaeological sites, physical remains provide the material foundation, while AR supplements the historical information that the remains cannot convey. The positive association between AR content quality and experiential authenticity suggests that visitors' perceptions of authenticity may also be related to the quality of digital interpretation accompanying the physical remains. This finding concerns differences in perceived content quality among AR users; it does not establish whether AR use itself enhances authenticity relative to a non-AR experience. Notably, Tangibles and AR content quality were weakly correlated ($r = 0.108$; HTMT = 0.122), indicating that visitors' evaluations of the physical environment and digital content were relatively independent. This may reflect their different evaluation targets, although visitors' evaluation criteria were not directly examined in this study. Their separate associations with experiential authenticity support treating them as distinct stimulus dimensions within the S–O–R framework.

Visitors who experience greater authenticity are more likely to develop emotional connections to the site [26,42,44]. However, experiential authenticity showed a larger indirect association with heritage conservation intention through place attachment than its direct association in the baseline model. A study on nomadic community-based tourism in Mongolia also found that place attachment significantly mediated the relationship between cultural authenticity and sustainable tourist behavior, highlighting the importance of emotional ties to a place in sustainable tourism [80]. This finding is consistent with research linking place attachment to environmentally responsible behavior [20,21], but it differs from studies that found inconsistent effects of place attachment at natural heritage sites [7,23,24]. This discrepancy may reflect heritage type and how historical and cultural narratives are presented, although this explanation requires further investigation through comparisons across heritage types.

Mediation analysis showed that Tangibles are associated with place attachment both directly and indirectly through experiential authenticity, although direct association was weak ($\beta = 0.105$, $f^2 = 0.014$). In the baseline model, the direct association between AR content quality and place attachment was nonsignificant, whereas the indirect association through experiential authenticity was significant. However, the direct association was sensitive to the experiential authenticity item specification. These patterns are descriptive: differences in statistical significance do not establish a statistically significant difference between the corresponding TAN and AR content quality path coefficients. Both stimuli showed significant specific indirect associations with heritage conservation intention through experiential authenticity and place attachment. By contrast, the indirect associations through experiential authenticity alone were small ($\beta = 0.034$ and 0.035). The direct EA–HCI association (H4a) and the indirect associations through EA alone (H6a and H6b) were also sensitive

to model specification, with confidence intervals including zero in the alternative model (Table A5). These findings suggest that greater interpretive weight should be placed on the associations involving place attachment.

From the perspective of sustainable heritage use, AR content quality is indirectly associated with heritage conservation intention through experiential authenticity and place attachment. This suggests that the potential relevance of digital technology to conservation-related intentions may depend on visitors' perceptions of authenticity and their emotional connections to the site. These findings can inform AR interpretation design, although its effects on actual conservation behavior remain untested.

The interaction of Tangibles and AR content quality with experiential authenticity was not significant; thus, H9 was not supported. At low, average, and high levels of Tangibles, AR content quality was significantly and positively associated with experiential authenticity. However, no statistically significant evidence indicated that the strength of this relationship varied across Tangibles levels. These findings suggest that physical and digital quality can each be associated with experiential authenticity without a significant interaction. As Tangibles reflect overall perceived physical quality rather than specific physical–digital alignment, the nonsignificant moderation should be interpreted cautiously. Exploratory TOST supported equivalence within ± 0.20 but not ± 0.10.

5.1. Theoretical Implications

This study makes four main theoretical contributions.

First, this study distinguishes physical environment quality from AR content quality as two stimulus dimensions within the S–O–R framework for heritage tourism. Their weak correlation, together with their positive associations with experiential authenticity, suggests that visitors' evaluations of physical and digital quality do not need to coincide closely for both to be relevant to authenticity experiences. The theoretical contribution lies in the identification of how these distinct quality evaluations relate to a shared psychological response, providing a more differentiated account of AR-enhanced heritage experiences than an undifferentiated view of overall quality.

Second, the findings highlight experiential authenticity as an important link between both physical and digital quality evaluations and place attachment. In the baseline model, Tangibles showed both a weak direct association with place attachment and an indirect association through experiential authenticity, whereas AR content quality was associated with attachment primarily through experiential authenticity. The indirect associations involving both experiential authenticity and place attachment remained significant across alternative authenticity item specifications, although the direct AR content quality–attachment association varied. Thus, the findings emphasize the relevance of authenticity to the relationship between digital content quality and visitors' connections to the site, without implying that this is the only possible pathway.

Third, the presented evidence is consistent with the theoretically proposed indirect pathway linking experiential authenticity, place attachment, and heritage conservation intention. Experiential authenticity was associated with heritage conservation intention through place attachment, while its direct association was weak and sensitive to model specification. This highlights the mediating role of place attachment in connecting authenticity with conservation intention.

Fourth, this paper provides empirical evidence on the associations of physical and digital quality evaluations, experiential authenticity, and place attachment with heritage conservation intention at AR-enhanced archaeological heritage sites. Previous studies have largely focused on the impact of authenticity on satisfaction, visit intention, or AR use

intention [15,81]. This study was focused on conservation-related behavioral intentions and their psychological correlates in archaeological heritage contexts.

5.2. Practical Implications

First, heritage site managers should attend to both the maintenance of the physical environment and AR content quality. Tangibles and AR content quality were significantly and positively associated with experiential authenticity. Therefore, managers should protect archaeological remains, maintain environmental cleanliness, and improve signage, while enhancing the relevance, clarity, and comprehensibility of AR information. For sites where the original appearance is difficult to discern, archaeologically grounded digital reconstructions can help visitors understand the existing remains, supporting site presentation and use that communicate heritage value and encourage its conservation.

Second, AR presentation design should consider visitors' experiential authenticity and emotional connections to the site. In the baseline model, AR content quality was associated with place attachment primarily through experiential authenticity, while place attachment showed a comparatively strong association with conservation intention. Practical recommendations based on these associations are inferred from conservation intentions, and their effects on actual conservation behavior remain to be validated. For example, within the Mojiaoshan Pilgrimage Route AR Experience, digital reconstructions of palace architecture and historical activities can be aligned with on-site remains such as terraces and building foundations, with the aim of helping visitors understand the historical functions and cultural significance of the remains and supporting their connections to the site. This suggests that managers should prioritize the connection between digital content and physical remains in AR design and consider visitors' experiential authenticity, place attachment, and heritage conservation intention when assessing the value of AR applications.

Third, visitors should be provided with accessible ways to participate in conservation. The strong positive relationship between place attachment and heritage conservation intention suggests that managers could explain the site's vulnerability and routine conservation work during visits. At the end of the visit, they could offer guidance on responsible visitor behavior and information about volunteer opportunities. Because this study measured heritage conservation intention, the effects of these measures on actual behavior still need evaluation.

5.3. Limitations and Future Research

First, a cross-sectional survey was employed, which identified relationships consistent with theoretical expectations. However, it could not establish causal relationships among experiential authenticity, place attachment, and heritage conservation intention or confirm their proposed temporal sequence. Similarly, the explained variance in HCI across the original, reversed, and parallel models further indicates that the proposed ordering cannot be uniquely established based on these data (Table A1). Longitudinal or experimental designs could be used to examine this process further in future studies.

Second, this study primarily relied on self-reported data; heritage conservation intention reflects a behavioral tendency rather than actual conservation behavior. Whether respondents actually visited the site and used AR was also based primarily on self-reports. Online purposive recruitment may overrepresent digitally engaged visitors, and the one-year recall window may cause authenticity ratings to reflect remembered overall impressions rather than immediate experiences. Although the principal associations remained stable across shorter recall windows, these findings cannot exclude self-selection or recall bias. The depth of AR engagement was also not independently verified. Future research could

incorporate AR usage logs, admission records, on-site intercept surveys, and data on actual conservation behavior to validate these findings.

Third, this study focused exclusively on the Mojiaoshan Pilgrimage Route AR Experience in the Liangzhu Ancient City Ruins Park. Different sites may vary in their state of preservation and use of AR. Future research could conduct cross-site comparisons to assess whether the relationships identified in this study hold across different contexts. The absence of a non-AR comparison group also limits conclusions regarding the additional contribution of AR use itself; future research could compare comparable AR and non-AR visitor groups.

Fourth, the sample primarily consisted of Chinese visitors; visitors from different cultural backgrounds may differ in their judgments of authenticity, place attachment, and sense of responsibility for heritage conservation. Future research could include international visitors for cross-cultural comparisons.

Fifth, this study did not account for individual factors such as heritage knowledge or prior AR experience. In future work, the moderating effects of these variables could be examined and visitor experiences could be compared across different AR presentation formats and modes of interaction. The covariate-adjusted results support the stability of the principal associations, although unmeasured confounding cannot be excluded.

Sixth, the interaction effect between Tangibles and AR content quality was not statistically significant; however, this result does not prove that no interaction exists. The exploratory TOST supported equivalence within ±0.20 but not ±0.10 standardized slope units. Future research could directly assess historical and spatial alignment between physical remains and AR content, alongside overall Tangibles, and moderation could be examined across heritage contexts.

Finally, the indirect associations through both experiential authenticity and place attachment remained positive and statistically significant across the examined alternative EA item specifications (Table A6), although some individual associations varied. This supports the stability of these specific indirect associations but does not resolve the content-validity concern. Although EA2 and EA3 refer to the site, their wording does not explicitly connect inspiration or uniqueness to its historical and cultural meanings. Consequently, the EA measure may partly reflect broader experiential appreciation, and associations involving EA cannot be attributed exclusively to authenticity. Future research could refine these items to express their intended historical and cultural meaning more explicitly and assess whether experts and visitors distinguish that meaning from aesthetic appreciation or novelty. The overall construct treatment of place attachment may likewise obscure distinctions between its two dimensions. Future research could also distinguish place identity from place dependence and incorporate historical accuracy into the measurement of AR content quality.

6. Conclusions

Drawing on S–O–R theory, this study addressed how Tangibles and AR content quality relate to heritage conservation intention through experiential authenticity and place attachment among visitors to the Mojiaoshan Pilgrimage Route AR Experience. Both stimuli were positively associated with experiential authenticity and showed significant indirect associations with conservation intention through experiential authenticity and place attachment, which is consistent with the theoretically proposed pathway. In the baseline model, Tangibles also showed a weak direct association with place attachment, whereas AR content quality was related to attachment mainly through authenticity. Place attachment showed a stronger direct association with conservation intention than experiential authenticity in the baseline model. The weak direct association of experiential

authenticity (H4a) and the small indirect associations through experiential authenticity alone (H6a and H6b) were sensitive to model specification and should therefore be interpreted cautiously. Tangibles did not significantly moderate the relationship between AR content quality and experiential authenticity. Within this AR-enhanced archaeological setting, both physical environment and digital content evaluations were indirectly associated with conservation intention through experiential authenticity and place attachment.

From the perspective of visitor psychology and heritage conservation, this study offers insights into how physical environment and AR content evaluations relate to conservation intention. These associations suggest that site maintenance and digital interpretation could jointly attend to experiential authenticity and place attachment; the effects of such measures on actual conservation behavior remain to be validated. These findings provide practical guidance for sustainable heritage site management and for the responsible application of digital innovation in archaeological heritage tourism.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The data presented in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AR	Augmented reality
S–O–R	Stimulus–organism–response
PLS-SEM	Partial least squares structural equation modeling
TAN	Tangibles
ACQ	AR content quality
EA	Experiential authenticity
PA	Place attachment
HCI	Heritage conservation intention
AVE	Average variance extracted
HTMT	Heterotrait–monotrait ratio
VIF	Variance inflation factor
SRMR	Standardized root mean square residual
RMSE	Root mean square error
MAE	Mean absolute error
CVPAT	Cross-validated predictive ability test
IA	Indicator average
CI	Confidence interval
SD	Standard deviation
STDEV	Standard deviation
IRB	Institutional Review Board

Appendix A

Table A1. Comparison of the original sequential mediation model and competing models.

Model/Indirect Path	TAN Indirect β [95% CI]	ACQ Indirect β [95% CI]	R^2 (EA)	R^2 (PA)	R^2 (HCI)
A: EA → PA → HCI	0.135 [0.106, 0.169]	0.139 [0.110, 0.172]	0.340	0.381	0.479
B: PA → EA → HCI	0.012 [0.002, 0.024]	0.010 [0.002, 0.019]	0.502	0.181	0.479
C: Parallel mediation—via EA	0.034 [0.006, 0.065]	0.035 [0.006, 0.065]	0.340	0.181	0.480
C: Parallel mediation—via PA	0.202 [0.153, 0.254]	0.159 [0.113, 0.208]	—	—	—

Note: N = 635. Models were estimated using PLS-SEM with 5000 bootstrap resamples. Values are standardized specific indirect effects with 95% percentile confidence intervals. R^2 values are unadjusted. The two rows for Model C report indirect effects through EA and PA within the same parallel mediation model.

Table A2. Supplementary moderation and equivalence analyses using item-mean scores.

Equivalence Bounds	Slope Difference	95% CI	90% CI	TOST *p*	Equivalence
±0.10	−0.055	[−0.185, 0.074]	[−0.164, 0.054]	0.249	Not established
±0.20	−0.055	[−0.185, 0.074]	[−0.164, 0.054]	0.014	Supported

Note: N = 635. Analyses used standardized item-mean scores. The slope difference compares TAN at +1 and −1 SD. Equivalence bounds (±0.10 and ±0.20) were exploratory and specified during revision.

Table A3. Robustness analysis with covariate adjustments.

Hypothesis	Path	M0: Baseline	M1: Three Covariates	M2: Five Covariates
H1a	TAN → EA	0.386 ***	0.393 ***	0.390 ***
H1b	TAN → PA	0.105 **	0.113 **	0.113 **
H2a	ACQ → EA	0.398 ***	0.396 ***	0.395 ***
H2b	ACQ → PA	0.031 ns	0.044 ns	0.045 ns
H3	EA → PA	0.551 ***	0.530 ***	0.532 ***
H4a	EA → HCI	0.087 *	0.087 *	0.087 *
H4b	PA → HCI	0.635 ***	0.617 ***	0.618 ***
H5a	TAN → EA → PA	0.213 ***	0.208 ***	0.207 ***
H5b	ACQ → EA → PA	0.219 ***	0.210 ***	0.210 ***
H6a	TAN → EA → HCI	0.034 *	0.034 *	0.034 *
H6b	ACQ → EA → HCI	0.035 *	0.034 *	0.034 *
H7a	TAN → PA → HCI	0.067 **	0.070 **	0.070 **
H7b	ACQ → PA → HCI	0.020 ns	0.027 ns	0.028 ns
H8a	TAN → EA → PA → HCI	0.135 ***	0.129 ***	0.128 ***
H8b	ACQ → EA → PA → HCI	0.139 ***	0.130 ***	0.130 ***

Note: Values are standardized path coefficients or specific indirect effects. M0 = baseline model; M1 adjusts for age, education, and visit history; M2 additionally adjusts for gender and occupation. Covariates predict EA, PA, and HCI. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns = not statistically significant. Occupation was dummy-coded with students as the reference category.

Table A4. Results of multigroup analysis by visit history.

Path	First-Time β	Repeat β	Δβ	Permutation *p*
TAN → EA	0.411	0.354	0.057	0.362
TAN → PA	0.076	0.142	−0.067	0.372
ACQ → EA	0.364	0.440	−0.075	0.221
ACQ → PA	0.052	−0.001	0.053	0.476
EA → PA	0.578	0.518	0.060	0.418
EA → HCI	0.061	0.137	−0.076	0.317
PA → HCI	0.646	0.622	0.024	0.721
TAN → EA → PA → HCI	0.154	0.114	0.039	0.216
ACQ → EA → PA → HCI	0.136	0.142	−0.006	0.863

Note: First-time visitors ($n = 402$); repeat visitors ($n = 233$). Δβ represents the difference between group-specific estimates (first-time minus repeat). All permutation *p*-values exceeded 0.05.

Table A5. Comparison of the baseline and alternative models.

Path	Baseline β	Alternative β	Alternative 95% CI
Direct Paths			
TAN → HCI	—	0.049	[−0.016, 0.114]
ACQ → HCI	—	−0.017	[−0.078, 0.044]
EA → HCI	0.087	0.077	[−0.002, 0.160]
Specific Indirect Paths			
TAN → EA → PA	0.213	0.213	[0.171, 0.257]
ACQ → EA → PA	0.219	0.219	[0.177, 0.262]
TAN → EA → HCI	0.034	0.030	[−0.001, 0.065]
ACQ → EA → HCI	0.035	0.031	[−0.001, 0.065]
TAN → PA → HCI	0.067	0.066	[0.024, 0.112]
ACQ → PA → HCI	0.020	0.019	[−0.024, 0.066]
TAN → EA→ PA → HCI	0.135	0.134	[0.105, 0.167]
ACQ → EA→ PA → HCI	0.139	0.138	[0.109, 0.170]

Note: The alternative model adds TAN → HCI and ACQ → HCI to the baseline model. "—" indicates paths not specified in the baseline model. The 95% confidence intervals were obtained using 5000 bootstrap resamples.

Table A6. Sensitivity analysis of EA measurement specifications.

Path	Four EA Items	EA1 and EA4 Only	Excluding EA2	Excluding EA3
TAN → PA	0.105 (0.003)	0.168 (<0.001)	0.139 (<0.001)	0.121 (0.001)
ACQ → PA	0.031 (0.393)	0.086 (0.016)	0.057 (0.117)	0.050 (0.166)
EA → PA	0.551 (<0.001)	0.444 (<0.001)	0.493 (<0.001)	0.525 (<0.001)
EA → HCI	0.087 (0.019)	0.072 (0.041)	0.063 (0.082)	0.098 (0.007)
ACQ → PA → HCI	0.020 (0.396)	0.056 (0.018)	0.037 (0.119)	0.031 (0.169)
TAN → EA → PA → HCI	0.135 (<0.001)	0.098 (<0.001)	0.117 (<0.001)	0.124 (<0.001)
ACQ → EA → PA → HCI	0.139 (<0.001)	0.107 (<0.001)	0.126 (<0.001)	0.127 (<0.001)

Note: Values are standardized path coefficients (β), with two-tailed bootstrap *p*-values in parentheses. All specifications use the same sample (N = 635) and 5000 bootstrap resamples.

Table A7. Sensitivity analysis by time since visit.

Path	Full Sample, $n = 635$	6 Months, $n = 593$	3 Months, $n = 489$
TAN → EA	0.386 [0.327, 0.446]	0.377 [0.313, 0.440]	0.397 [0.329, 0.466]
TAN → PA	0.105 [0.037, 0.176]	0.102 [0.029, 0.174]	0.102 [0.022, 0.185]
ACQ → EA	0.398 [0.337, 0.456]	0.403 [0.343, 0.460]	0.378 [0.310, 0.442]
ACQ → PA	0.031 [−0.039, 0.103]	0.029 [−0.043, 0.103]	0.023 [−0.058, 0.103]
EA → PA	0.551 [0.481, 0.619]	0.542 [0.471, 0.613]	0.526 [0.448, 0.602]
EA → HCI	0.087 [0.014, 0.162]	0.082 [0.009, 0.156]	0.108 [0.027, 0.185]
PA → HCI	0.635 [0.569, 0.698]	0.642 [0.577, 0.704]	0.629 [0.563, 0.696]
TAN → EA → PA	0.213 [0.172, 0.257]	0.204 [0.163, 0.250]	0.209 [0.164, 0.259]
ACQ → EA → PA	0.219 [0.178, 0.262]	0.218 [0.178, 0.264]	0.199 [0.157, 0.246]
TAN → EA → HCI	0.034 [0.005, 0.065]	0.031 [0.003, 0.061]	0.043 [0.010, 0.076]
ACQ → EA → HCI	0.035 [0.006, 0.065]	0.033 [0.004, 0.063]	0.041 [0.010, 0.072]
TAN → PA → HCI	0.067 [0.023, 0.114]	0.065 [0.019, 0.113]	0.064 [0.014, 0.117]
ACQ → PA → HCI	0.020 [−0.025, 0.066]	0.019 [−0.028, 0.066]	0.014 [−0.037, 0.066]
TAN → EA → PA → HCI	0.135 [0.106, 0.169]	0.131 [0.102, 0.165]	0.131 [0.100, 0.168]
ACQ → EA → PA → HCI	0.139 [0.110, 0.172]	0.140 [0.111, 0.174]	0.125 [0.095, 0.159]

Note: Values are standardized β [95% CI] from 5000 bootstrap resamples. The 6- and 3-month subsamples restrict the full sample to respondents who visited within the shorter recency window.

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