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Author (s):	Ngo Nhat Phuong
Affiliation (s):	Van Lang University, Ho Chi Minh City, Vietnam
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Adaptive Interaction Design for Heritage Visitor Experience: An Evidence-Based Framework from the Imperial City of Hue, Vietnam

Ngo Nhat Phuong*

Faculty of Fine Arts and Design, Van Lang University, Ho Chi Minh City, Vietnam

ABSTRACT Investment in heritage interpretation continues to grow, yet most of that effort is directed at supplying more content and incorporating new technologies, while comparatively little systematic attention is given to how the visit itself should be organised. This study translates evidence on visitor barriers and interaction needs into design requirements for an interpretive system at the Imperial City of Hue, Vietnam. Data from 153 visitors were analysed at item level across three visit contexts: independent individual, independent social, and guided tour. The main difficulties concerned interpretive quality, spatial orientation and journey continuity rather than simple access to content, and twelve of the sixteen items differed significantly across contexts after Holm correction. Most notably, the two independent groups reported almost identical wayfinding barriers yet differed markedly in their expressed need for wayfinding support, indicating that a comparable barrier does not entail a comparable need for assistance. From four empirical patterns, the study formulates four evidence-informed design requirements and organises them into a two-layer architecture, in which shared interactive components belong to a core layer while the degree of guidance they exert belongs to an adaptive orchestration layer. This structure proposes a way for a single shared system to operate differently across use situations without fragmenting the service.

INDEX TERMS adaptive interaction design, design requirements, heritage interpretation, Imperial City of Hue, visitor experience

Highlights

- Barriers at a large open-air heritage site centre on comprehension, orientation and journey continuity rather than on the availability of information.
- Twelve of sixteen items differ significantly across visit contexts, so a uniform interpretive system cannot serve every use situation.
- Comparable barriers do not entail comparable needs: two independent

*Corresponding Author: ngophuong20072002@gmail.com

groups reported the same wayfinding difficulty but very different expectations of guidance.

I. INTRODUCTION

A large-scale tangible heritage complex holds its value in a fabric spread across a wide area, yet that fabric does not translate automatically into visitor understanding. Interpretation closes this gap, but in practice it is often equated with supplying information through signage, printed material or mobile applications. Tilden [1] argued that information is not interpretation, and that more information does not guarantee deeper understanding.

The Imperial City, the central precinct of the Complex of Hue Monuments inscribed by UNESCO in 1993 [2], is a characteristic instance: a walled ensemble of dispersed structures on a largely outdoor route. Most of the fabric has now been restored, and Hue holds eight UNESCO-recognised heritage properties across tangible, intangible and documentary categories [3]. Conservation has accordingly shifted towards visitor experience: Phan [3] calls for wider use of digital technology, while the city has adopted a visitor-centred smart heritage-city direction [4, 5]. These directions set an objective but leave open how the experience should be organised.

The challenge grows once the visit is recognised as heterogeneous. Visiting alone, with family or friends, or on a guided tour differs in autonomy, pace and available information, making visit context a condition that shapes experience rather than a peripheral demographic variable. Here, interaction design organises content, space and behaviour into a structured journey, while technology remains the means of delivery rather than the object of study.

The literature leaves this step open. One line examines how major institutions integrate digital technology into interpretive practice [6], or analyses spatial configuration to explain movement; research on spatial connectivity in museums shows that integration and visibility govern visitor flow, though it rests on spatial data alone and excludes the subjective dimensions of the experience [7]. A second line documents differences between visitor groups, and these are by now well established.

A third line responds to those differences by adapting system output. Context-aware recommenders generate individual routes from visitor preferences and situational conditions, with in situ evaluation at two open-

air archaeological parks reporting high satisfaction among nearly two thousand users [8]. Profile-based mobile recommenders return points of interest according to expressed preferences [9], while augmented-reality wayfinding studies examine factors shaping system acceptance in historic districts [10]. Together, these studies establish the practical feasibility of adaptation in heritage settings.

What this work largely treats as given is the composition of the system itself: adaptation is evaluated within a complete application, while the prior question of which components should remain shared and which should vary is rarely addressed. The nearest antecedent is the multilayer approach of Not and Petrelli [11], which separates customisation, context awareness and adaptivity within one platform; however, its layers are defined by adaptation mechanisms rather than by evidence about which aspects of the experience should differ across use situations.

The gap therefore lies not in detecting visitor differences or in the technical means of responding to them, but in converting evidence about those differences into a stated system structure: which components should form a shared base, and which should vary with context of use. Without this step, design tends towards either disconnected recommendations or a uniform system applied across use situations.

This study therefore asks how the barriers and interaction needs of visitors at the Imperial City can be converted into design requirements for a system that maintains a shared interactive base while adapting to visit context.

A. HERITAGE INTERPRETATION AND VISITOR EXPERIENCE

Heritage communicates through mediation, and the traces the fabric carries are not self-evident to a first-time visitor. Tilden [1] states the founding principle: interpretation is not the transmission of facts but the revelation of meaning and relationship, and it takes effect only when it connects with something already present in the visitor's experience.

Ham [12] develops this into a working framework in which interpretive content requires a clear theme, coherent organisation and relevance to the recipient, while Moscardo [13] adds its behavioural side: visitors move through a site mindfully or mindlessly, and how content is organised largely determines which. At the level of policy, the ICOMOS charter [14] treats interpretation as part of site management rather than an optional service.

Together these positions yield a distinction that matters for design: reaching content and understanding content are separate achievements calling for different interventions. This is the first experiential domain: interpretive access and quality.

B. HERITAGE VISIT AS A SPATIAL AND INTERACTIVE JOURNEY

At a large open-air site such as the Imperial City, content must also operate within a journey through space, in which visitors repeatedly locate themselves, move between structures, pause and assemble what they encounter into a sequence. The contextual model of Falk and Dierking [15] places the physical dimension alongside the personal and the sociocultural, showing that space shapes what visitors meet and in what order, and poorly connected areas are bypassed regardless of what they display [7]. Orienting movement is therefore a basic condition of the experience.

The journey perspective supplies the temporal dimension. Visitor journey mapping sets out the touchpoints of a service and exposes the gaps between them [16], while research on service journeys analyses stages as connected phases rather than independent events [17]. In heritage, each location may be fully interpreted while the visit as a whole lacks a connecting thread, leaving visitors with fragments rather than cumulative understanding.

Continuity also depends on opportunities for participation, since a coherent visit may remain passive if visitors only observe [18]. Two further domains follow: spatial orientation, which enables the journey to proceed, and journey continuity and participation, which allows separate encounters to accumulate into a connected experience.

C. DIGITAL MEDIATION, VISIT CONTEXT AND ADAPTIVE ORCHESTRATION

The three domains specify what an interpretive system must support, but leave open through what medium and under which conditions of use. Treating digital technology as an independent domain obscures its mediating role. Petrelli et al. [19] compose material and digital elements into a single experience, Hornecker and Ciolfi [20] treat technology as a means of organising the encounter between visitor and object, and Pei [21] finds its effectiveness depends chiefly on integration with interpretive intent. Digital mediation is therefore a cross-cutting condition affecting all three domains.

The remaining question is for whom. Falk and Dierking [15] show that experience is formed simultaneously by the individual, the setting and the accompanying others; Hassenzahl and Tractinsky [22] treat it as the product of system, person and situation; and Neuhofer et al. [23] stress context-dependent personalisation.

Within heritage this heterogeneity has generated substantial work on personalisation [24, 25], while inclusive design seeks provision usable across diverse users [26]. Personalisation may fragment the service; a uniform system may fail to answer different use situations.

This study distinguishes adaptive orchestration from personalisation by the level at which change occurs. Personalisation alters what is delivered to a user; context-aware adaptation changes output according to situational conditions; orchestration retains a shared set of components and varies how they operate. Route guidance, content depth, narrative form and interaction level become adjustable parameters of a common infrastructure rather than separate service versions. Adaptivity is therefore the level at which shared support is configured, not a further domain or feature.

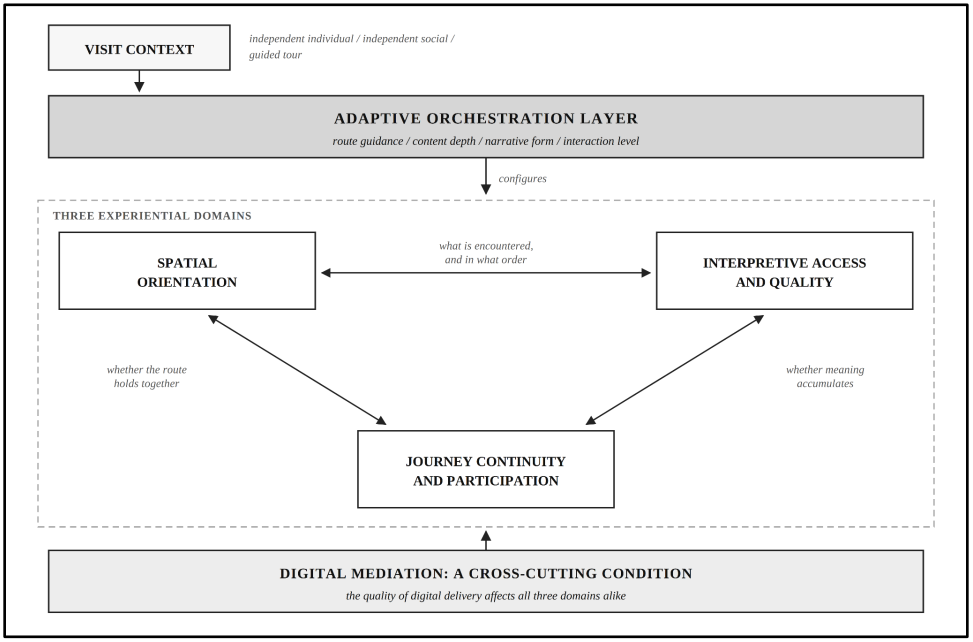


Figure 1. Conceptual framework: three experiential domains, a cross-cutting delivery condition, and an adaptive orchestration layer. Double-headed arrows between the domains indicate mutual dependence

These arguments yield the framework in Figure 1. The three domains are interdependent: spatial orientation shapes which content is encountered and in what sequence, interpretive quality determines whether those encounters become meaningful, and journey continuity depends on both. That the adaptive layer carries no barrier item is deliberate: adaptivity expresses an expectation about how experience should be organised rather than a response to a reported obstacle.

The conceptual contribution is to separate what remains shared from what varies by the role a component plays rather than by the domain to which it belongs. A component may remain in the core layer while the degree of support it provides is adjusted through the adaptive layer, and visit context enters as an input that configures this shared system. The framework is proposed as an interpretive design structure derived from the evidence below, not as an explanatory model.

II. METHOD

The study is conducted as an empirical case study within an evidence-based design approach, using the Imperial City of Hue to examine visitor barriers and needs as inputs to design requirements. The conceptual framework provides an interpretive structure for the aspects examined, while the survey supplies empirical evidence for design reasoning rather than for a predictive model of visitor behaviour.

Data were collected in June 2026 at the Imperial City through an online questionnaire administered to visitors who were on site at the time. A total of 153 valid responses entered the analysis. Recruitment used on-site non-probability convenience sampling and may therefore be subject to selection bias. The sample is not statistically representative of all visitors to the Imperial City, so findings are interpreted as evidence from the sampled visitors rather than as population estimates. The visit form reported by respondents was grouped into the three visit contexts shown in Table I: independent individual, independent social, and guided tour. This classification reflects different use situations in terms of autonomy, pace and available support rather than three fixed types of visitors. The categories are therefore treated as operational classifications based on respondents' reported form of visit, not as an empirically derived or validated visitor typology. Participants were informed of the purpose of the study, took part voluntarily, and all responses were processed anonymously.

TABLE I
SAMPLE CHARACTERISTICS BY VISIT CONTEXT

Visit context	Original visit form	n	%
Independent individual	Visiting alone	51	33.3
Independent social	Visiting with friends or family	47	30.7
Guided tour	Visiting on a guided tour	55	35.9
Total	-	153	100.0

The study uses self-reported perception data because it examines perceived barriers and expectations of system support, which cannot be inferred reliably from observed behaviour alone. Behavioural observation would complement these data by showing how reported perceptions relate to actual conduct.

TABLE II
CONCEPTUAL COMPONENTS AND MEASUREMENT ITEMS

Component	Barrier items	Need items
Spatial orientation	Wayfinding	Wayfinding support; Interactive map
Interpretive access and quality	Information access; Interpretation access; Content clarity	Information presentation; Storytelling media
Journey continuity and participation	Narrative continuity; Experiential interaction	Experiential touchpoints
Digital mediation (cross-cutting)	Quality of existing digital solutions	Digital interaction; Physical-digital integration
Adaptivity (orchestration layer)	None by design	Personalisation; Personalised route

Note. Five-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). The full instrument, in the original Vietnamese and in English translation, is available from the author. The adaptivity layer carries no barrier item by design, following the argument set out in Section I.C.

The instrument comprises sixteen items on a five-point Likert scale: seven address current experiential barriers and nine address interaction needs. The items were organised according to the conceptual framework in Section I (Table II) to identify which aspects of the experience require support and whether that support varies by context, so the number of items per component was not balanced by design. This mapping provides a theoretical basis for item content, but the instrument was not independently validated as a psychometric scale.

Cronbach's alpha was 0.71 for the barrier items and 0.91 for the need items,

indicating internal consistency within each group; these coefficients are not used here to justify aggregation into composite scores. Analysis therefore remains at item level because each item represents a distinct design issue, and aggregation could obscure differences within the same domain. As shown in Section III.C, the need for an interactive map varies little across contexts, whereas the need for wayfinding support varies considerably. Item-level analysis therefore preserves these design-relevant differences.

The analysis proceeds in two steps: descriptive statistics for each item across the whole sample and by context, followed by tests of difference between the three contexts for each item using one-way analysis of variance, replaced by Welch's test where Levene's test indicated unequal variances, with Tukey or Games-Howell post-hoc comparisons accordingly. Effect sizes are reported as eta squared. Because sixteen tests were conducted in parallel, the Holm correction was applied to control the family-wise error rate, and every conclusion about difference rests on the corrected p value.

A final analytical step translates empirical findings into design requirements through four stages: identifying item-level patterns of barriers and needs, examining contextual differentiation, interpreting those patterns through the conceptual framework and relevant literature, and formulating the resulting design requirements. These requirements are evidence-informed design inferences rather than statistically verified causal relationships.

III. RESULTS

A. OVERALL PATTERNS OF VISITOR BARRIERS AND NEEDS

Among the barrier items, the ranking in Table III reveals a split within the domain of interpretive access and quality. The two access items, information access (M = 3.31) and interpretation access (M = 3.48), record the lowest scores, whereas the clarity and appeal of content ranks second (M = 3.77). The two lowest-rated barriers therefore concern access to content, while the higher-rated item within the same domain concerns its clarity and appeal. Beyond this domain, the remaining higher-rated barriers fall within spatial orientation and journey continuity and participation, with wayfinding highest (M = 3.92).

The need items display a different pattern. All nine fall between 3.88 and 4.14, a range of only 0.26 points against 0.61 for the barrier items. Ratings of support needs are therefore uniformly high and narrowly spread across

types of support. Notably, the ranking of needs does not mirror the ranking of barriers. Wayfinding is the highest barrier, yet the need for wayfinding support is the lowest among the need items; conversely, personalisation is the highest-rated need although no barrier item corresponds to it. The two distributions barely overlap: the highest barrier and the lowest need differ by only 0.04 points.

B. DIFFERENCES ACROSS VISIT CONTEXTS

The divergence between barriers and needs becomes clearer once visit context is taken into account. After Holm correction, twelve of the sixteen items differ significantly across the three contexts, with effect sizes ranging from 0.086 to 0.185; the two largest are the need for storytelling media (η^2 = 0.185) and the assessment of existing digital solutions (η^2 = 0.165). The three contexts form profiles that are not parallel across the two item groups: the independent social group is highest on five of seven barrier items, the independent individual group is highest on six of nine need items, and the guided-tour group is lowest on most items in both groups. The context reporting the most obstacles is therefore not the context expressing the strongest need for support; these two roles belong to different contexts. The only two exceptions, the need for wayfinding support and for information presentation, both fall to the independent social group and both concern the degree to which visitors are guided as they approach space and content.

In practical terms, small-to-moderate effect sizes suggest that visit context modifies specific support needs rather than producing wholly different visitor experiences. The four remaining items show no significant difference and they fall into two groups distinguished by their mean level. Two need items, interactive map (M = 4.12; η^2 = 0.033) and physical - digital integration (M = 4.06; η^2 = 0.055), combine a high mean with no significant variation across the three contexts. By contrast, the barriers of information access (M = 3.31; η^2 = 0.039) and interpretation access (M = 3.48; η^2 = 0.002) are both lower than the salient barriers and weakly differentiated by context. The absence of contextual variation therefore occurs at two distinct levels of overall rating.

TABLE III
ITEM MEANS BY VISIT CONTEXT AND TESTS OF DIFFERENCE

Item	Whole sample *M* (*SD*)	Ind. (51)	Soc. (47)	Tour (55)	Test	*F*	*p* (Holm)	η^2	Group pattern
Barriers									
Wayfinding	3.92 (0.93)	4.12	4.21	3.47	ANOVA	11.11	<0.001	0.129	Ind, Soc > Tour
Content clarity	3.77 (0.86)	3.71	4.17	3.49	Welch	11.34	<0.001	0.108	Soc > Ind, Tour
Narrative continuity	3.77 (0.91)	3.59	4.26	3.53	Welch	13.89	<0.001	0.128	Soc > Ind, Tour
Quality of existing digital solutions	3.75 (0.90)	3.84	4.17	3.29	Welch	16.28	<0.001	0.165	Ind, Soc > Tour
Experiential interaction	3.65 (0.94)	3.35	4.15	3.51	Welch	12.52	<0.001	0.128	Soc > Ind, Tour
Interpretation access	3.48 (0.97)	3.55	3.47	3.44	ANOVA	0.18	0.832	0.002	ns
Information access	3.31 (0.95)	3.57	3.15	3.20	ANOVA	3.03	0.155	0.039	ns
Needs									
Personalisation	4.14 (0.77)	4.45	4.15	3.86	ANOVA	8.67	0.002	0.104	Ind > Tour
Interactive map	4.12 (0.75)	4.22	4.23	3.95	ANOVA	2.52	0.168	0.033	ns
Storytelling media	4.12 (0.80)	4.47	4.26	3.67	Welch	15.30	<0.001	0.185	Ind, Soc > Tour
Experiential touchpoints	4.07 (0.66)	4.20	4.28	3.78	Welch	8.19	0.003	0.112	Ind, Soc > Tour
Physical-digital integration	4.06 (0.74)	4.24	4.13	3.84	ANOVA	4.36	0.058	0.055	ns
Digital interaction	4.03 (0.74)	4.22	4.17	3.75	Welch	6.45	0.012	0.086	Ind, Soc > Tour
Personalised route	3.97 (0.87)	4.16	4.23	3.56	Welch	8.84	0.002	0.123	Ind, Soc > Tour
Information presentation	3.93 (0.81)	4.28	3.68	3.82	Welch	11.39	<0.001	0.096	Ind > Soc, Tour
Wayfinding support	3.88 (0.89)	4.35	3.55	3.73	ANOVA	13.00	<0.001	0.148	Ind > Soc, Tour

Note. Group columns report means; standard deviations by group are shown in Figure 2 for the spatial orientation items and are available from the author for the remaining items. Welch's test is used where Levene's test was significant, with Games-Howell post-hoc comparisons; Tukey is used otherwise. The p column reports Holm-corrected values across all sixteen tests; ns = not significant after correction. Ind = independent individual, Soc = independent social, Tour = guided tour

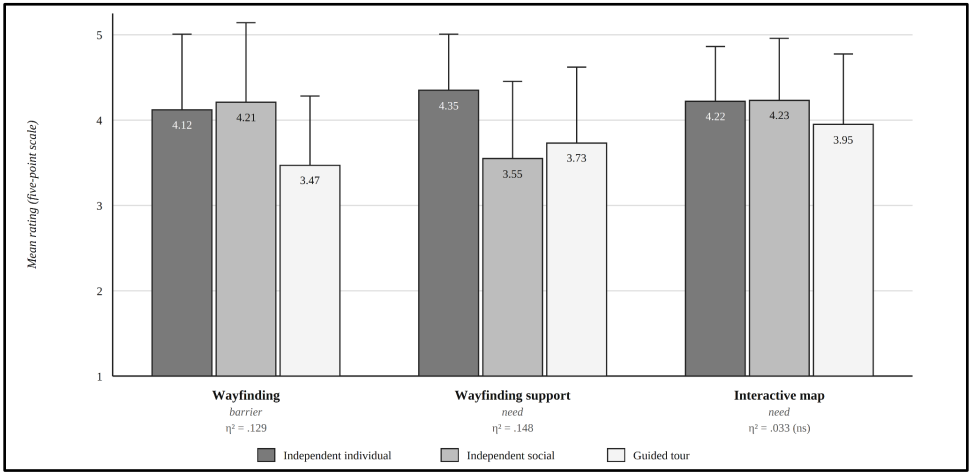


Figure 2. Barrier and need items within the spatial orientation domain, by visit context. Bars show group means and error bars show one standard deviation, with the effect size for the difference across contexts reported beneath each item

Note. The two independent groups differ by 0.09 points on the barrier item but by 0.80 points on the need item. The second difference is among the largest in the study, while the need for the tool itself does not vary significantly across contexts. In practical terms, visitors facing the same orientation difficulty expect markedly different amounts of guidance, although they want the same tool.

C. THE WAYFINDING CASE: WHEN OVERALL AVERAGES MASK CONTEXT

The mismatch between barriers and needs described in subsection A is most visible in the domain of spatial orientation, where it also exposes the limits of reading whole-sample averages alone. Across the sample, wayfinding is the highest barrier while the need for wayfinding support is the lowest among the need items, an apparently contradictory relationship. The pattern becomes clearer when the three contexts are examined separately.

The two independent groups report almost identical wayfinding difficulty ($M = 4.12$ and $M = 4.21$), yet their need for wayfinding support differs by 0.80 points ($p < 0.001$; Hedges' $g = 1.01$; $\eta^2 = 0.148$). A comparable barrier is therefore not accompanied by a comparable need for support. The whole-sample mean is thus the product of aggregating dissimilar profiles and does not adequately represent any of them.

Notably, this differentiation does not extend across the whole orientation domain. The need for an interactive map is almost identical in the two independent groups (M = 4.22 and M = 4.23) and does not differ significantly across the three contexts. Two items within the same domain therefore behave differently: the need for an interactive map is stable across contexts, while the need for wayfinding support is among the most strongly differentiated items in the study.

IV. DISCUSSION

A. FROM EMPIRICAL PATTERNS TO DESIGN REQUIREMENTS

The four empirical patterns reported in Section III are interpreted through the conceptual framework following the procedure set out in Section II. Each subsection identifies the pattern, makes the interpretive reasoning explicit and states the resulting design requirement; Table IV presents the same progression in parallel. The requirements are therefore not direct outputs of the statistical tests: the tests establish the differences and their magnitude, while their translation into requirements is grounded in the framework and the interpretive and visitor-experience literature.

From information access to meaningful interpretation. In interpretive access and quality, reaching content is rated as less of an obstacle than receiving it. This study reads the pattern through Tilden's distinction between information and interpretation [1] and gives specific form to Pei's observation [21] that the effectiveness of interactive systems depends on integration with interpretive aims rather than on the technology itself. It also bears on digital investment: analyses of major museums' digital strategies show that technology is expected both to raise interpretive quality and to increase engagement [6], and the present data indicate where that expectation should be focused. The two access items are the only barriers that do not differ by context, whereas the need for storytelling media carries the largest effect size in the study (η^2 = 0.185). Design requirement: prioritise interpretive quality over information volume, and treat narrative form as an adjustable parameter.

Comparable barriers, divergent support needs. In spatial orientation, the two independent groups report comparable wayfinding difficulty yet differ considerably in their need for support. Falk and Dierking [15] suggest that when visitors travel together, part of the orientation function is performed within the group, so expectations of the system fall even though the obstacle

persists. This extends the social dimension of their model from the construction of meaning to the formation of support expectations, and complements spatial-configuration research, which cannot readily capture such differences [7]. Although the data cannot confirm the mechanism, they establish that a comparable barrier does not necessarily accompany a comparable need for support. Design requirement: retain the orientation tool as a shared component while varying the degree of guidance it exerts by visit context.

TABLE IV
FROM EMPIRICAL EVIDENCE TO PROPOSED DESIGN REQUIREMENTS

Empirical evidence	Observed pattern	Interpretive rationale	Proposed design requirement
Access barriers comparatively low; content clarity $\eta^2 = 0.108$; storytelling media $\eta^2 = 0.185$	Access is less problematic than clarity and narrative form	Interpretive quality is the main design concern [1], [21]	Prioritise interpretive quality; vary narrative form
Similar wayfinding barriers; support need differs; map need stable	Tool need is stable, while guidance need varies	Tool provision and guidance intensity play different roles [15]	Retain a shared orientation tool; vary guidance by context
Continuity and interaction barriers follow similar patterns; touchpoint need remains high overall	Journey fragmentation and participation are linked	Connected touchpoints support journey continuity [16, 17, 19]	Organise touchpoints as a connected participatory sequence
Personalisation is the highest-rated need; personalised route is context-sensitive; no matching barrier item by design	Personalisation concerns how support operates	Adjustment should organise shared support rather than create separate services [24, 26]	Place route, content, narrative and interaction adjustment at an orchestration tier

Note. Statistics are drawn from Table III; *p* values are Holm-corrected and ns denotes no significant difference after correction.

From a fragmented journey to continuity and participation. The two barrier items follow almost identical patterns: difficulty in linking information across sites and the sense that participatory activity is lacking are both highest in the independent social group ($\eta^2 = 0.128$), while the need for experiential touchpoints remains consistently high. Read through the conceptual framework, these are interpreted as interdependent aspects of one experiential condition: when stops are interpreted individually but remain unconnected, adding technology only increases the number of

contact points without creating a thread. This is consistent with Petrelli et al. [19] and extends the journey-mapping approach [16, 17] to an open-air setting in which visitors determine their own route. Design requirement: organise touchpoints as a sequence with a narrative logic, in which each point carries the thread forward and creates an opportunity to act.

Personalisation as an orchestration principle. Personalisation is the highest-rated need, while no corresponding barrier item was included by design. It is therefore read as a requirement concerning how support should operate across contexts rather than as a response to one measured difficulty. That reading differs from much heritage research [24], [25], which approaches personalisation as a technical capability. Treated as a discrete feature it tends to produce separate service versions and the fragmentation against which inclusive design cautions [26]; treated as an orchestration principle, a shared system can still adapt to different use situations. Design requirement: place the adjustment of route, content depth, narrative form and interaction level at an orchestration tier rather than treating personalisation as a function alongside the others.

B. AN EVIDENCE-BASED ADAPTIVE INTERACTION FRAMEWORK

The four requirements are not independent: the first three describe functional components, the fourth describes how those components are adjusted. Their relationship is one between two tiers, presented in Figure 3, and it is the point at which the organising principle stated in Section I takes its specific form.

Organising principle: The boundary between the two layers cannot be drawn by assigning each experiential domain to one layer. The wayfinding case in Section III.C makes the distinction visible: within spatial orientation, the need for an interactive map is broadly stable across contexts (η^2 = 0.033), whereas the need for wayfinding support is strongly differentiated (η^2 = 0.148). Two items in the same domain reflect two roles: the support component that is provided, and the degree of guidance that component should exert. The framework therefore separates the layers by role rather than by domain, the core layer maintaining shared components while the adaptive layer adjusts how they operate for each use situation. This is an evidence-based design inference, not a structure already verified through a prototype.

The core layer: Components belong to this layer where a high mean combines with little contextual differentiation, indicated by a comparatively small effect size and no significant difference after correction. Table V summarises the items that most clearly represent the three evidential patterns relevant to the proposed architecture. The third group is instructive because it too shows no differentiation yet carries the opposite meaning: information access and interpretation access are rated lower than the salient barriers, making them lower-priority intervention points rather than foundational components. The core layer defined in this way is narrow, and deliberately so: most other components vary by context and do not belong to a shared base. Its specific components are set out in Section C.

TABLE V
CLASSIFICATION OF DESIGN REQUIREMENTS BY EMPIRICAL EVIDENCE

Classification	Criterion	Corresponding items
Core requirement	High mean, comparatively small effect size, no difference after correction	Interactive map (4.12; $\eta^2 = 0.033$); Physical-digital integration (4.06; $\eta^2 = 0.055$)
Adaptive requirement	High mean, significant difference across visit contexts	Storytelling media ($\eta^2 = 0.185$); Wayfinding support ($\eta^2 = 0.148$); Personalised route ($\eta^2 = 0.123$); Experiential touchpoints ($\eta^2 = 0.112$); Personalisation ($\eta^2 = 0.104$)
Lower-priority requirement	Mean below the salient barriers, no difference after correction	Information access (3.31); Interpretation access (3.48)

Note. The table summarises the items that most clearly exemplify the three evidential patterns identified from Table III. Uniformity across contexts supports a core requirement only when it accompanies a high mean; where it accompanies a comparatively low mean, it indicates a lower intervention priority instead.

The adaptive orchestration layer. This layer does not create a different system for each group but adjusts how the core layer operates, through four parameters, anchored to context-sensitive need items: the route parameter is tied to the need for wayfinding support and for a personalised route; content depth to the need for information presentation; narrative form to the need for storytelling media; and interaction level to the need for experiential touchpoints and digital interaction.

The three contexts described in Section III translate into three configurations of these parameters, set out in Section C. They are tied to use situations rather than to fixed attributes of users: the same visitor may therefore fall into different contexts on different visits. In the proposed implementation, visitors self-select their current visit mode at entry; automatic context detection is not assumed or tested in this study.

Unlike feature-based personalisation, this framework varies the operating parameters of a shared infrastructure rather than duplicating the service, thereby balancing inclusive provision [26] with context-sensitive support [24]. Theoretically, it treats situation as an input to the system [22] and uses separation by role to determine which components remain shared and which are adjusted [23].

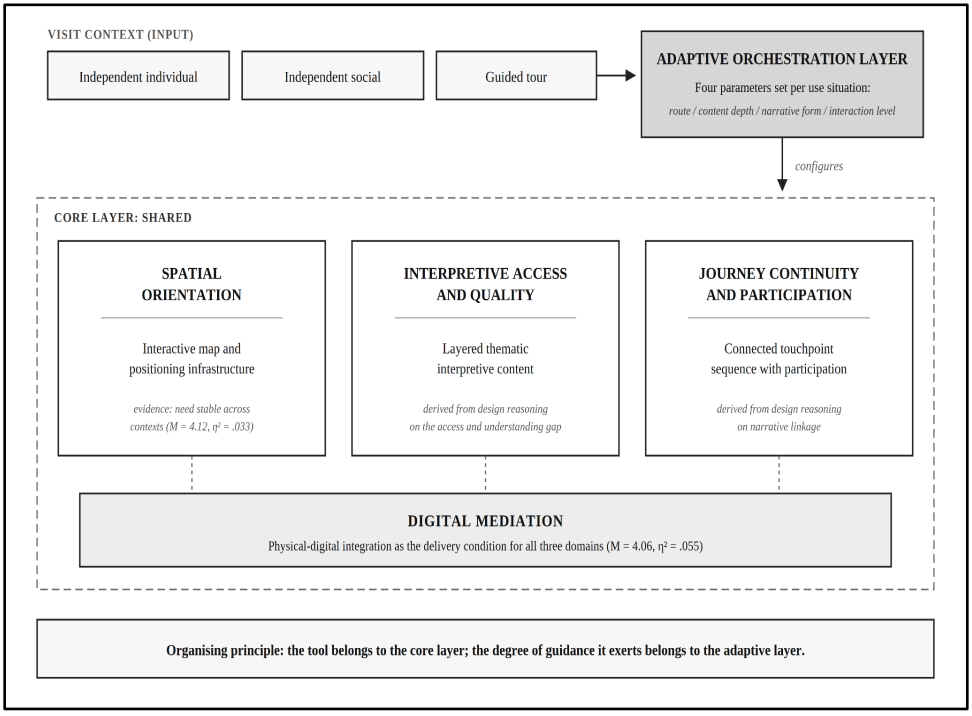


Figure 3. The core-and-adaptive interaction architecture. Visit context is an input to the orchestration layer, which configures a shared core layer.
Note. Means and effect sizes shown in the figure are drawn from Table III. The core layer is deliberately narrow: it holds only the components for which demand is high and does not vary significantly across visit contexts.

C. DESIGN PROPOSITIONS FOR THE IMPERIAL CITY OF HUE

The framework in Section B specifies the role of each component but not its form of implementation. Applied to the Imperial City, where every intervention must respect the conservation requirements of a World Heritage property, the study proposes five propositions designed to minimise physical intervention and remain reversible where possible.The first four describe shared system components, while the fifth specifies how their operation may be adjusted across visit contexts.

Restructure on-site interpretive signage. This barrier is relevant to the presentation of on-site interpretive content and therefore supports revising the physical information layer alongside digital provision ($M = 3.77$). The proposal is to reduce text density, strengthen visual hierarchy, replace long blocks of text with images or diagrams, and limit each panel to a single main idea. Because it does not depend on personal devices, this measure serves every group of visitors. Physical changes should use existing or freestanding sign structures rather than attachment to historic fabric.

Establish a shared positioning and map layer for the whole precinct. An interactive map on mobile devices displays the visitor's current position and the nearby structures, accessed through QR codes at Ngo Mon and the secondary gates. This is one of only two items that combine a high mean with no differentiation by context ($M = 4.12$; $\eta^2 = 0.033$) and is therefore suited to serve as shared infrastructure for all visitors. A mobile-first approach limits fixed hardware, while QR access points should use existing visitor infrastructure rather than historic surfaces.

Organise digital content in layers of depth. Each stop uses the same structure of a short summary, an interpretive narrative and extended source material. Visitors may stop at the basic level or continue further without altering their route. Personalisation is thus delivered through depth of engagement rather than through separate bodies of content. Because content is delivered digitally, adaptation can occur without additional physical intervention to the historic fabric.

Link the stops into a participatory narrative thread. Each stop ends with a content link leading to the next and a short on-site interactive activity. The two elements are combined because the corresponding barriers also appear together in the data: difficulty in linking information across sites ($M = 3.77$) and the sense that participatory activity is lacking ($M = 3.65$) are both

highest in the same context and carry the same effect size ($\eta^2 = 0.128$). On-site activities should therefore rely on removable or portable touchpoints and avoid permanent fixtures that affect historic fabric or circulation.

Orchestrate one system across three visit contexts. Users select one of three modes at the outset. The independent mode increases route guidance and narrative content; the group mode reduces guidance and gives priority to shared experiences; the guided-tour mode reduces route guidance and gives greater emphasis to content that supplements the guide's commentary. All three modes run on the same infrastructure and differ only in their orchestration parameters. Because the variation occurs at the software level, adaptation does not require separate physical installations for each visit context.

Read in this sequence, the first four proposals form a single support system rather than separate technologies: signage clarifies meaning on site, the map sustains orientation, layered content adjusts the depth of reception, and the touchpoints maintain continuity, while the orchestration layer determines how each component is activated in a given context. The value of the framework therefore lies not in adding tools at the Imperial City but in reorganising the relationship between tool, content and journey.

D. LIMITATIONS AND FUTURE RESEARCH

First, the sample was recruited through on-site convenience sampling and consists mainly of young, first-time visitors. This group may be particularly reliant on interpretive infrastructure, which makes it relevant here, but its composition may also shape the profile observed within each visit context. A stratified sample including returning visitors and older age groups would test the findings and show whether site familiarity should become an additional orchestration parameter.

Second, the data capture perceived experience rather than observed behaviour. The argument nevertheless rests on differences between contexts and on the divergence between barriers and needs rather than on absolute values; combining survey data with on-site observation would strengthen these profiles.

Third, the move from empirical patterns to design requirements remains an evidence-informed inference, and the proposed architecture has not been validated through prototyping or user testing. Its feasibility, usability and experiential effects should be evaluated with users from all three contexts,

first for the shared core and then for the orchestration layer.

Fourth, several potentially confounding variables were not measured. Prior heritage knowledge, site familiarity and available visit time may vary across visit contexts and may also shape perceived barriers and support needs. Future studies should measure them to distinguish their influence from that of visit context.

E. CONCLUSION

This study asked how evidence on visitor barriers and interaction needs can be converted into design requirements for an interpretive system that maintains a shared base while adapting to visit context. Evidence from 153 visitors at the Imperial City of Hue indicates that the main difficulties concern spatial orientation, interpretive quality and journey continuity rather than access to information or technology, and that many item-level patterns vary across contexts. The contribution is threefold. Empirically, barriers and needs do not covary: groups may face comparable obstacles yet expect different levels of support, so whole-sample averages can conceal decisive differences. Methodologically, the study sets out a procedure for converting user evidence into design requirements, each anchored to a specific data pattern. Conceptually, it proposes a two-layer architecture, a shared core layer with a context-adaptive orchestration layer, designed to let one system operate differently across use situations without duplicating the service. The procedure and the principle of separating layers by role may transfer to other open-air heritage complexes; the specific parameter configurations remain tied to the Imperial City and the present sample.

Author Contribution

Ngo Nhat Phuong: sole author

Conflict of Interest

The author declares no financial or non-financial conflict of interest in the subject matter or materials discussed in this manuscript.

Data Availability Statement

The anonymized data associated with this study will be provided by the author upon reasonable request.

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