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Mediating heritage through design: Participatory approaches to post-digital transformation

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Abstract: This research explores how design mediates the digital transformation of cultural heritage through hybrid and multisensory installations in archaeological contexts. Using the *Case Romane del Celio* in Rome as a pilot site for the European project *HeritAdapt*, it aims to redistribute visitor flows and promote sustainable tourism by enhancing the intangible value of minor sites. The study contributes to the post-digital museology debate by framing design as a critical, participatory practice operating across physical and virtual dimensions, fostering collaboration among engineering, management and restoration. Combining Service Design, Extended Reality and Artificial Intelligence technologies, qualitative research and iterative prototyping guided the creation of an integrated experience along the entire visitor journey. The approach seeks symbiotic interventions that ensure long-term sustainability, stakeholder involvement, storytelling-based engagement, heritage preservation and promotion. Following a testing phase, the project will develop toolkits and guidelines for GLAMs, enabling adaptable, accessible, and context-grounded digital interventions in heritage scenarios.

Keywords: participatory design; multisensory experience; service design; heritage enhancement

1. Introduction

The contemporary debate on the promotion and preservation of Cultural Heritage (CH) has intensified in recent years, driven by the challenges posed by mass tourism and overtourism (Vadrucci, 2025). Cities such as Rome and Venice stand as emblematic Italian cases, where the imbalance between visitor flows and the capacity of local infrastructures and services erodes both tangible and intangible heritage, while also generating negative impacts on residents and urban economies (Bisht, 2025b, Butler & Dodds, 2022).



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These issues highlight the need for cities to develop tourism management strategies operating across multiple levels and sectors that both influence and are influenced by tourism itself (Bisht et al., 2025a). Among these, CH plays a crucial role (Ye et al., 2024), encompassing the ensemble of tangible and intangible expressions that narrate the history of a civilization and contribute to shaping contemporary identities (Lohman & Punja, 2020).

Preserving both dimensions is essential to maintaining a territory's cultural identity (Lohman & Punja, 2020; Ye et al., 2024). However, conservation must be complemented by sustainable promotion strategies capable of balancing cultural valorisation, social inclusion, and responsible tourism management (Demiröz et al., 2025; Vadrucchi, 2025).

In response to these challenges, cultural institutions have increasingly explored digital strategies for their services and visitor experiences. Following the COVID-19 pandemic, the push toward digital transition rapidly accelerated, leading Galleries, Libraries, Archives and Museums (GLAMs) into a new phase of digitalization defined as Post-Digital Museology (PDM), in which digital takes on a normative and pervasive presence in museum operations and functions (Mason, 2022; Mason et al., 2025). From this perspective, digital tools are no longer add-ons, but integral to institutional missions, organizational structures, and daily workflows, shifting focus from learning "about" technology to operating consciously "with" it (Parry et al., 2025), as illustrated in the *One by One* project applying the Baltimore Principles.

In this context, PDM promotes a holistic cultural transformation that goes beyond the implementation of digital tools, moving toward organizational strategies and collaborative practices (Parry, 2013). Through methodologies such as Design Thinking (DT), GLAMs can address complex challenges, developing processes based on empathy, experimentation, and a greater openness to risk and failure as part of the innovation process (Mason, 2022).

From the perspective of visitor experience, the PDM paradigm requires a rethinking of how CH is enjoyed. Digital media no longer merely supports the interpretation of contents, but contributes to building hybrid experience ecosystems where physical and digital dimensions intertwine (Mason et al., 2025). Technologies such as mobile apps, mixed reality, websites, and interactive tools allow visitors to access personalized content, actively participate in interpretative processes, and continue the museum experience beyond the institution's physical space (Nikolaou, 2024). In this way, the PDM emerges as a relational, participatory, and interactive space, capable of strengthening the social role of GLAMs in the production, promotion, and sharing of cultural knowledge. Addressing these challenges requires approaches capable of integrating technological, organizational and experiential dimensions.

Within the PDM framework, the discipline of Service Design (SD) can play a pivotal role in developing sustainable solutions that account for the multiplicity of factors shaping CH systems, acting as an agent of systemic, participatory, and cultural transformation (Bosco et al., 2023). Rooted in a Human-Centered perspective, SD elaborates interventions based on a

comprehensive understanding of the context and of the relationships among stakeholders, identifying needs, resources, and opportunities through qualitative research and co-design processes (Villari, 2022; Stickdorn et al., 2018).

Thanks to its collaborative and integrative approach, SD is particularly effective in multidisciplinary contexts (Bosco et al., 2023; Maye & Claisse, 2023), where it supports dialogue across domains ranging from engineering to researchers in architectural history, representation and conservation and from cultural management to communication. Rather than producing isolated artefacts, SD acts as a mediating framework that aligns perspectives, languages, and priorities, promoting coherence among stakeholders and enhancing the overall sustainability of the system (Villari, 2022).

Building on these premises, the role of the designer emerges as particularly relevant in addressing the challenges posed by PDM. This research investigates how designers, working within interdisciplinary teams, can contribute to new approaches to the valorisation of Cultural Heritage Sites (CHS). In particular, the study explores how design practices can mediate between technological innovation, visitor experience, and heritage preservation.

To address this question, the research was conducted through a case study in an archaeological site, involving an interdisciplinary team composed of researchers in architectural history, design and restoration, engineers, designers, and CH managers. The study adopts a Research through Design (RtD) approach (Godin et al., 2014), employing iterative exploration and rapid prototyping to investigate how DT methodologies and SD practices can generate knowledge about the integration of digital technologies in heritage contexts.

The selected case study for the project is the *Case Romane del Celio* (CRC) in Rome, an underground archaeological complex composed of a stratified architectural system of Roman domestic spaces dating from the third to the fifth century CE. Despite its remarkable historical and artistic value, the site suffers from low visitor numbers and limited economic sustainability, which threaten its long-term conservation.

The design process resulted in a visitor experience concept enhanced by strategically positioned XR devices that disclose the site's intangible heritage, otherwise imperceptible. Rather than relying on informational displays or isolated XR moments, the intervention seeks a symbiotic integration of installations within the broader experiential framework. The visitor journey is thus conceived as a coherent and cohesive narrative system.

This has been made possible through an in-depth scenario and stakeholder analysis, which informed a long-term strategy for sustainable redevelopment, optimizing available technological assets to ensure high user satisfaction and experiential quality.

Ultimately, the project proposes a new perspective on heritage revitalization within the framework of PDM. Specifically, it explores how a SD approach can guide the integration of XR technologies within archaeological sites, grounded in a systemic understanding of the context, by prioritizing usability, narrative coherence, and long-term sustainability over technological novelty. In doing so, the study investigates how digital interventions can transform archaeological sites from spaces of passive visitation into environments of active and emotionally engaging exploration.

The paper first reviews the theoretical background on PDM and SD. It then presents the research methodology and the case study context, followed by the design process and resulting visitor experience concept. Finally, the discussion reflects on the implications of the project for the design of sustainable digital interventions in archaeological sites.

2. Related work

Before developing the design proposal for the CRC, a preliminary analysis of current practices integrating digital technologies in CHS was conducted. This investigation examined how Extended Reality (XR) applications and SD methodologies are currently adopted in heritage contexts. The review highlights emerging trends, opportunities, and limitations in the use of digital technologies to enhance visitor engagement, while identifying how SD contributes to shaping contemporary design practices for CHS.

2.1 *Extended reality application in museum and cultural heritage*

XR technology is expanding the tourism offer, enabling visitors to access different types of experiences such as XR products, AI-powered chatbots (Murphy et al., 2024), and Digital Tourism Experiences (Tjostheim et al., 2025). However, many CHS still implement digital technologies as isolated products, while only a limited number adopt multi-product systems capable of generating integrated experiences. Within the framework of the experience economy (Lorentzen, 2009), CHS that fail to provide engaging experiences risk losing attractiveness and visitors over time (Lupo et al., 2023).

Several initiatives demonstrate how XR technologies can reinterpret CH and enhance visitor engagement. The *Circus Maximus Virtual Reality Experience* allows visitors to explore immersive digital reconstructions of the ancient monument through VR (Circus Maximus Experience, 2019). Similarly, *Go Muse!*, a mobile application for the *MUSE Science Museum* in Trento, integrates augmented reconstructions of artefacts into the visitor journey, blending physical and digital interpretation layers (MUSE Trento's Science Museum, 2018).

XR also extends museum experiences beyond the architectural boundaries of cultural institutions. For example, Snapchat developed Augmented Reality (AR) experiences for the *Louvre Museum* through the *Augmented Egypt* project (Snapchat for Louvre, 2023), enabling

interaction with digital artefacts both inside and outside the museum. Comparable approaches have been applied in urban contexts, such as the *Olympic Game on Snapchat* experience for the Paris 2024 Olympic Games (Olympic Game on Snapchat, 2024), which overlays historical content onto contemporary spaces. In Rome, Baratta et al. (2018) developed an XR application conceived as an urban museum, allowing users to explore digital reconstructions of historical buildings through the interaction between real and virtual layers of the city.

Art institutions are also adopting XR to enhance engagement with artworks. The *Tate Britain Virtual Wing* brings eight paintings to life through augmented reality, allowing visitors to uncover hidden narratives and animations via their smartphones (Tate Britain Virtual wing, 2019). Similarly, the *Relief Map Museum* in Paris enriches its physical models of historical French cities with Microsoft HoloLens XR, enabling visitors to navigate interactive 3D representations of these urban landscapes (Microsoft, 2018).

Finally, the *St. Peter's Basilica 3D Virtual Tour* illustrates the democratizing potential of digital heritage by offering remote access to one of the world's most iconic religious and cultural sites (Basilica of Saint Peter, 2024). High-resolution navigation allows users to move through the basilica, examine artworks, and appreciate architectural details, demonstrating how digital technologies can expand accessibility and foster new forms of engagement with CH.

2.2 Service design for cultural heritage

The application of SD to CHS increasingly focuses on innovating the visitor experience through participatory approaches (Recupero et al., 2023; Bosco et al., 2023). Co-design plays a key role, reframing the process as designing "with" rather than "for" stakeholders such as museum staff, local communities, and researchers (Maye & Claisse, 2023; Bosco et al., 2023). This perspective extends to service "co-production", which involves tourists and local communities as co-producers of the service (Palumbo & Trocciola, 2015).

A second theme concerns the role of SD in supporting digital transformation, accelerated by the "imposed service innovation" triggered by the COVID-19 pandemic (Norrgrann et al., 2022). This shift is closely linked to "experience innovation", often leveraging social media and digital platforms to engage younger audiences (Ng et al., 2024), and is also applied to safeguard Intangible CH (Yu et al., 2020).

The expansion of digital transformation strategies within CHS has also stimulated new approaches to digital tourism services (Tjostheim et al., 2025). Beyond moving content online, these services can enhance accessibility for users unable to physically visit CHS, supporting more inclusive cultural experiences. In this context, the *Basilica San Pietro*

Experience illustrates how digital services can support heritage digitalization, generating economic resources while contributing to the preservation of cultural values.

2.3 Design practices

The current digital transformation of CHS (Lupo et al., 2023) is often characterized by the isolated deployment of digital tools such as VR headsets, tablets, and smartphones. This approach frequently overlooks user needs and the broader regenerative potential of XR (Baratta et al., 2018), resulting in fragmented single-product experiences within CHS. The case study at CRC shifts away from these isolated interactions toward a holistic design methodology aimed at systemic innovation through digital technologies, generating benefits for the wider heritage network (Joly et al., 2019). Reviewing contemporary design practices highlights two critical constraints that limit the successful adoption of digital systems across CHS:

2.3.1 Fragmentation and lack of narrative coherence

The different case studies show how digital technologies in the CH sector focus on creating single-product solutions or isolated virtual reconstructions. While case studies like the *Circus Maximus Virtual Reality Experience* demonstrate how the implementation of XR can create a coherent experience (Circus Maximus Experience, 2019). This fragmentation is problematic, as the coexistence of multiple, uncoordinated digital touchpoints can generate discontinuity in the visitor experience. In this sense, often in CHS experiences there is a lack of narrative coherence behind the single interactions.

2.3.2 User experience for all the stakeholders

The implementation of high-quality digital experiences introduces challenges related to cost, personnel dependency, and scalability, which undermine long-term sustainability for many CHS. From an economic and managerial perspective, complex installations require substantial financial investment and specialized interdisciplinary teams, increasing operational costs.

This barrier conflicts with the principles of holistic sustainable design, which require the simultaneous consideration of economic, social, and environmental sustainability (Taramsari et al., 2025). Many current solutions also depend on qualified staff for technical assistance and operation, limiting their usability in smaller sites or those with restricted budgets (Lupo et al., 2023).

At the user-experience level, CHS research often promotes the adoption of “latest technologies” to create more engaging experiences. However, meetings with the organization managing the CRC site suggested avoiding VR head-mounted displays, which, despite their popularity, present management and maintenance issues. This reveals a gap between research trends promoting innovative devices and the realities of long-term implementation in CH contexts, where newer technologies are not always suitable or sustainable. As a result, projects often focus mainly on digital application development,

overlooking the design of physical products and procedures that support a good UX for both visitors and site staff.

3 Methodology

Considering the Experience Economy framework applied to CH (Zhu et al., 2025), the adoption of a SD approach proved strategically effective for addressing the diverse needs of the CRC stakeholders (Bosco et al., 2023; Maye & Claisse, 2023).

SD, as a holistic and Human-Centered discipline, integrates DT with service-oriented methods to generate innovative value propositions through a deep understanding of user experience and multidisciplinary insights (Joly et al., 2019). This approach is particularly suited to the systemic complexity of contemporary archaeological contexts, enabling the simultaneous consideration of technological, experiential, managerial, and narrative dimensions (Villari, 2022; Recupero et al., 2023).

The methodological framework of the case study in CRC followed the Double Diamond (DD) model (see Figure 1), developed by the British Design Council in 2005 and consolidated within SD practices (Stickdorn et al., 2018); the model is articulated into the *Discover*, *Define*, *Develop*, and *Deliver* phases. These iterative stages combined SD analytical, co-design, and evaluation tools adapted to the site's specificities and to the project's research objectives.

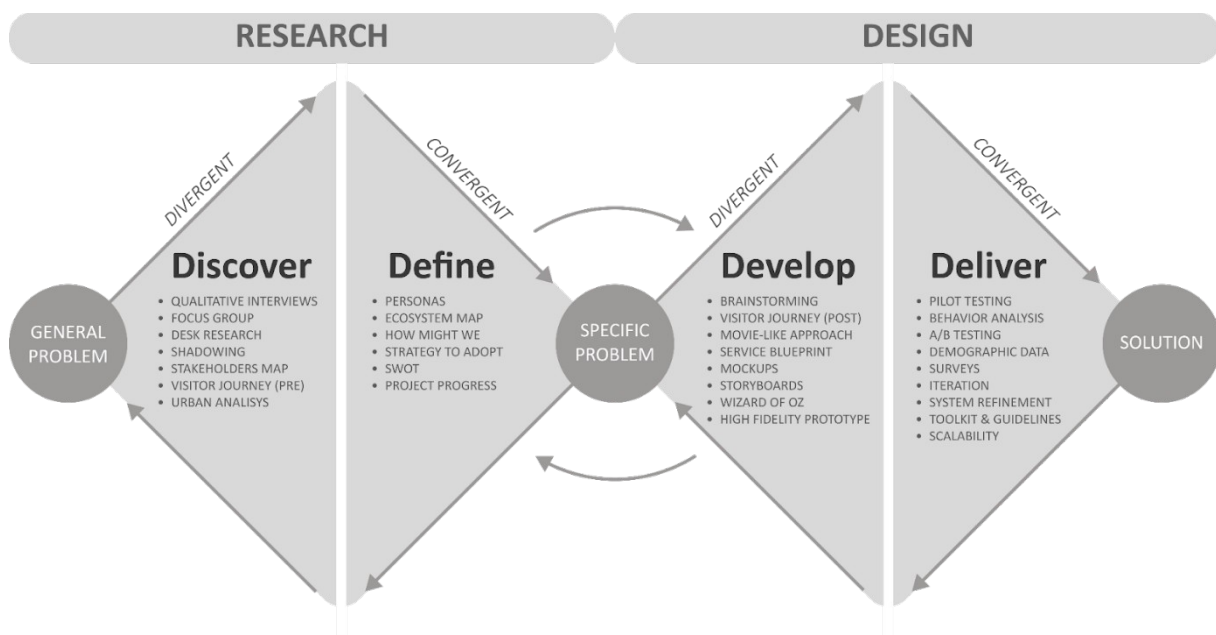


Figure 1 Double Diamond Model applied to the CRC intervention project.

The phases also included regular meetings with CoopCulture, the managing organization of CRC, enabling the integration of managerial constraints and operational guidelines into the overall design framework.

To support the contribution of the SD approach to the project, the following paragraphs present a synthesis of the models most relevant to the intervention, situated within the DD framework. These are complemented by additional studies, referenced but not detailed here, as they pertain to other disciplinary domains such as engineering and restoration.

3.1 Phase I: Discover

The scenario exploration aimed to develop a comprehensive understanding of the site's current condition. It began with desk research on the area's geo-historical context, carried out with restoration experts to identify the site's cultural values. This was followed by on-site visits to analyse the room layout and the existing cultural offering (see Figure 2).



Figure 2 Map of the archaeological site, with visitor route and images of the spaces.

Qualitative interviews and focus groups were conducted with CoopCulture, while on-site observations, including shadowing and non-participant observation, were used to analyse

visitors' spontaneous behaviours. Direct first-hand visits, both individually and within guided tours, provided additional insight into visitor perspectives and the site's experiential offering (see Figure 3).



Figure 3 One of the visits made to the CRC, to examine the behaviour of visitors and guides.

The urban context surrounding the archaeological site was analyzed, mapping pathways and points of interaction with local activities, as well as identifying neighboring cultural sites that may represent either competitive elements or opportunities for differentiation within a broader and more diversified tourist offer.

Visual tools were developed to synthesize the collected data and clarify the relationships among actors, processes, and touchpoints within the current system. The maps and models were intentionally simple and concise to ensure clarity of communication for team members from different disciplines and for external stakeholders. By distilling complex information into clear shared representations, these tools minimised fragmented understanding and divergent expectations, supporting the alignment of intervention strategies. This facilitated interdisciplinary synergy, coherent decision-making, and more effective communication, ultimately improving the productivity of the team.

3.1.1 Stakeholder map

The stakeholder map (see Figure 4) identifies the individuals, communities and institutions directly or indirectly involved in the project (Giordano et al., 2018). In the CRC project it supported attention to all stakeholder needs, preventing decisions that might overlook or negatively affect some of them, and ensured consideration of both spatial and broader human and contextual dimensions, contributing to a more sustainable intervention for the site and its surrounding environment.

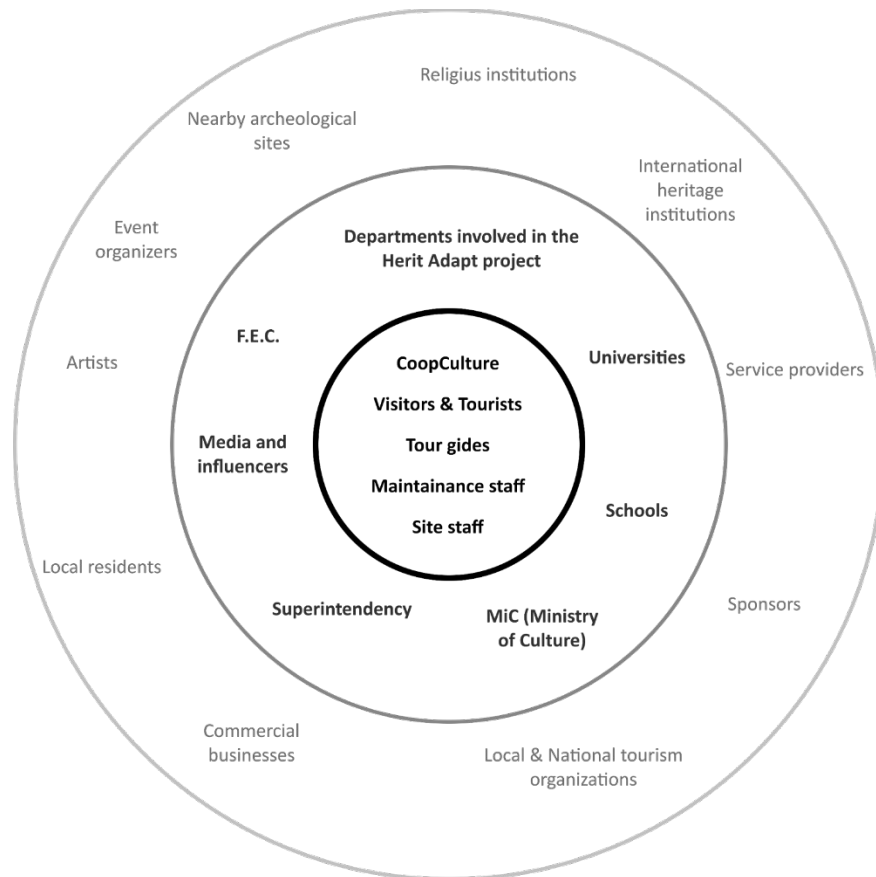


Figure 4 Map of CRC primary and secondary stakeholders.

3.1.2 Visitor journey pre intervention

The visitor journey (see Figure 5) outlines the visitor's path within the archaeological site, mapping the informational content tools available in each room and the types of visits currently offered, which are currently limited to self-guided visits, with or without an audio guide, and guided group tours led by a professional guide.

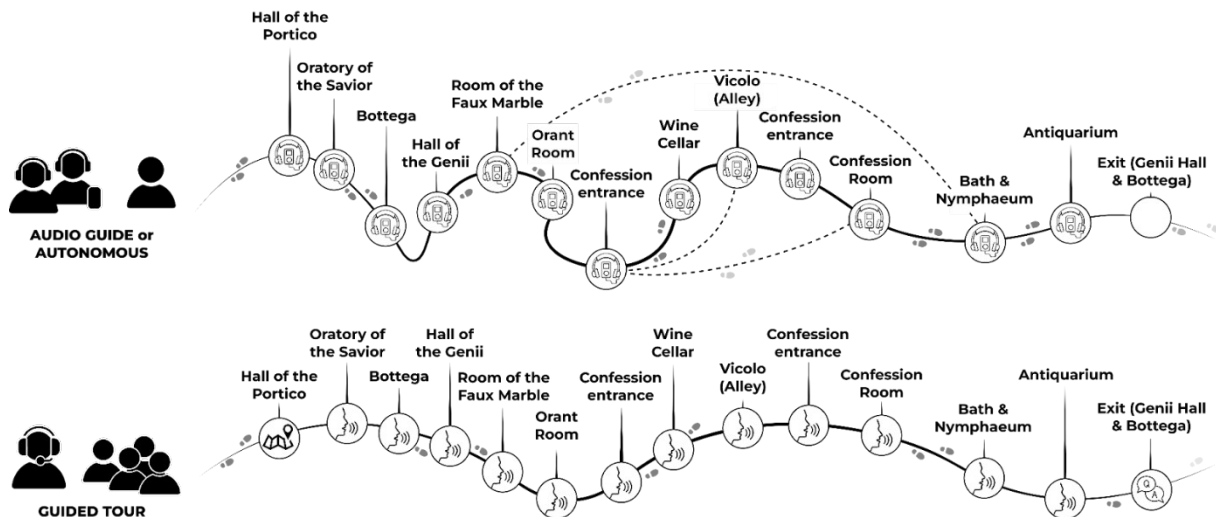


Figure 5 Visitor journey pre intervention.

3.2 Phase II: Define

In the context definition phase, the data collected during the *Discover* stage were synthesized to better understand the target audience and the experiential dynamics of the site.

3.2.1 Personas

A personas-based definition was developed to identify user clusters, not through fixed archetypes, but rather by examining their motivations, levels of knowledge, and expectations.

Three primary visitor profiles emerged:

- **Guided groups:** Composed mainly of European tourists, particularly Germans, who have previously visited Rome or are staying for longer periods. Their itineraries, curated by professional guides, combine major landmarks with lesser-known sites such as the Caelian Hill. During CRC visits, guides often rely on supplementary materials (e.g., maps, photographs). According to CoopCulture, non-European guided groups are uncommon, as short-stay international tourists typically prioritise major attractions;
- **Occasional visitors:** Predominantly Italian residents or domestic tourists familiar with the city and seeking alternative, less crowded experiences. Their visit to the CRC is often spontaneous, prompted by signage, social media, or curiosity. They follow flexible schedules, explore independently using audio guides, and generally spend more time on-site, valuing intimacy, authenticity, and cultural depth;

- **School groups:** Consisting of students from local primary and lower secondary schools, accompanied by teachers who prioritise educational value and manageable environments over mainstream attractions. The CRC offers tailored guided tours suitable for experiential learning. Student engagement, however, depends strongly on interactive, narrative, and media-based tools, which are more effective than traditional explanations or passive reading (Wang et al., 2024).

3.2.2 Ecosystem map

The ecosystem map (see Figure 6), adapted to the applied context of CRC, illustrates the various stages of the average visitor's experience, describing their expectations, needs, actions, touchpoints, and the people involved throughout the process.

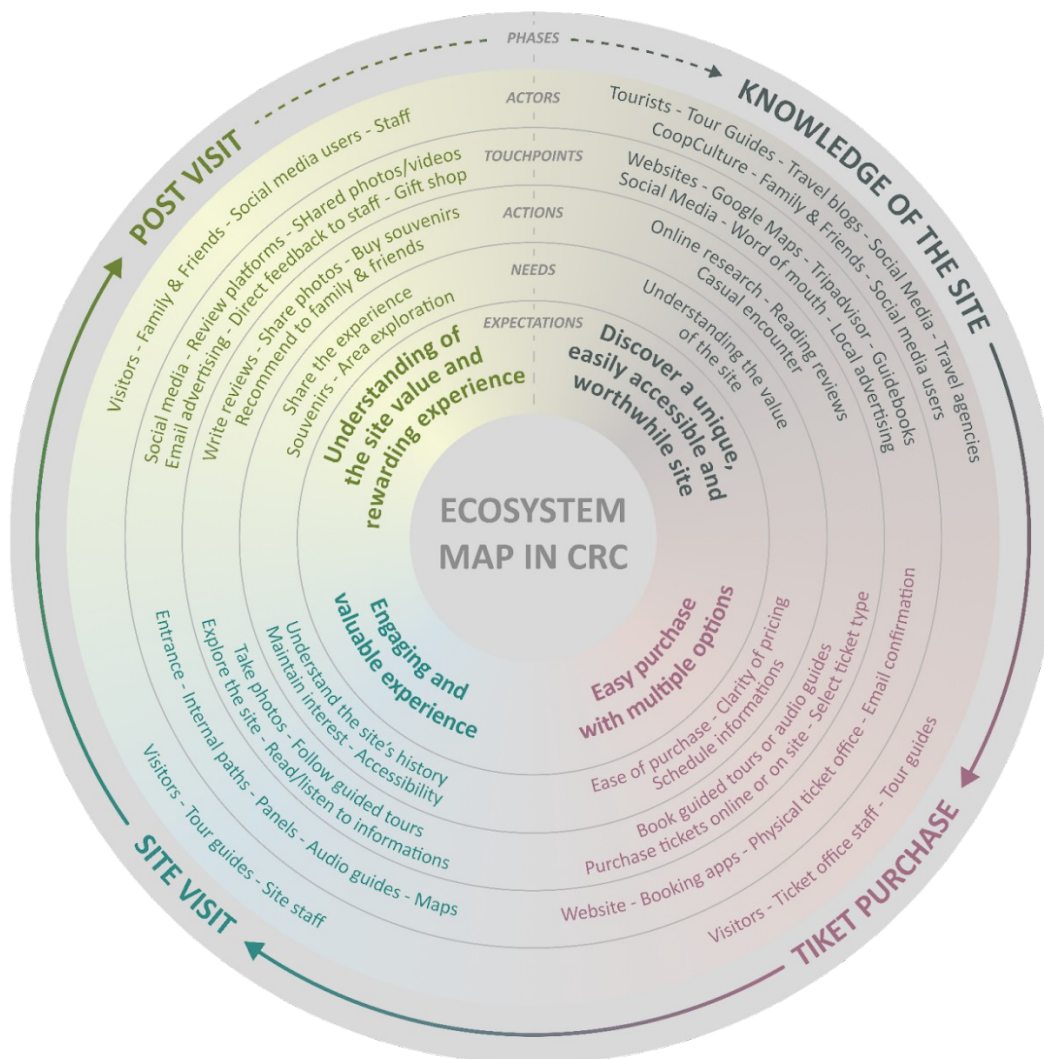


Figure 6 Ecosystem map of the visitor experience.

3.2.3 SWOT analysis

The final step, which condenses the overall analysis of the intervention scenario and outlines the strategies that can be adopted in the following phase, was the SWOT analysis (Dehghan et al., 2018), summarized as follows:

STRENGTHS: • Strategic location • High cultural value • Historical significance • Extensive archaeological complex • Modern Antiquarium • Authentic insight into daily life • Immersive visitor experience	WEAKNESS: • Low visitor flow • Limited visibility and recognition: • Underutilized spaces • Limited financial resources • Limited staff availability • Accessibility and usability issues • Competition with more famous attractions • Lack of technological innovation
OPPORTUNITIES: • Development of integrated tourist itineraries • Integration of digital and multimedia technologies • Temporary events and exhibitions: • Partnerships and cultural collaborations • Increasing visibility through digital communication	THREATS: • Competition from more popular sites • Maintenance and conservation constraints • Technological competition • Limited media and digital visibility: • Limited investment capacity: • Risks related to organizational crises • Risks related to external events

The context analysis highlighted several issues and opportunities that informed the decision to introduce XR installations at the CRC:

- **Low visibility and attendance:** Despite its cultural value, the CRC remains overshadowed by nearby major attractions like Colosseum, Circus Maximus, Palatine Hill, and is perceived as a secondary destination;
- **Conservation and management constraints:** The site's archaeological sensitivity limits physical interventions, requiring non-invasive, reversible, and conservation-compatible solutions;
- **Limited visitor experience:** The current route lacks narrative coherence, especially in the transition to the final exhibition space, the *Antiquarium*, and some areas are inaccessible, reducing the completeness of the visit;

- **Technological competition:** Other Roman sites increasingly adopt AR and immersive technologies, making the CRC less competitive from a digital standpoint;
- **Fragmented communication and low engagement:** The experience remains predominantly informational, with limited immersion, interactivity, and emotional resonance.

Based on these findings and consultations with CoopCulture, XR was identified as a strategic solution to:

- **Enhance narrative** readability and communicate historical stratification more effectively;
- **Integrate inaccessible** areas through digital reconstruction to offer a more comprehensive and inclusive visit;
- Create a more **immersive and interactive experience** that balances information and emotional engagement;
- **Strengthen connections** with the surrounding area through digital itineraries linking the CRC to other sites on the Caelian Hill;
- **Support guides and operators** with digital tools that enrich communication and cultural mediation.

3.3 Phase III: Develop

The intervention concept developed through the first two phases involves the implementation of ten installations distributed along the visitor path (see Figure 7). Each installation has been strategically designed to engage visitors dynamically and to foster an active relationship with the archaeological environment.

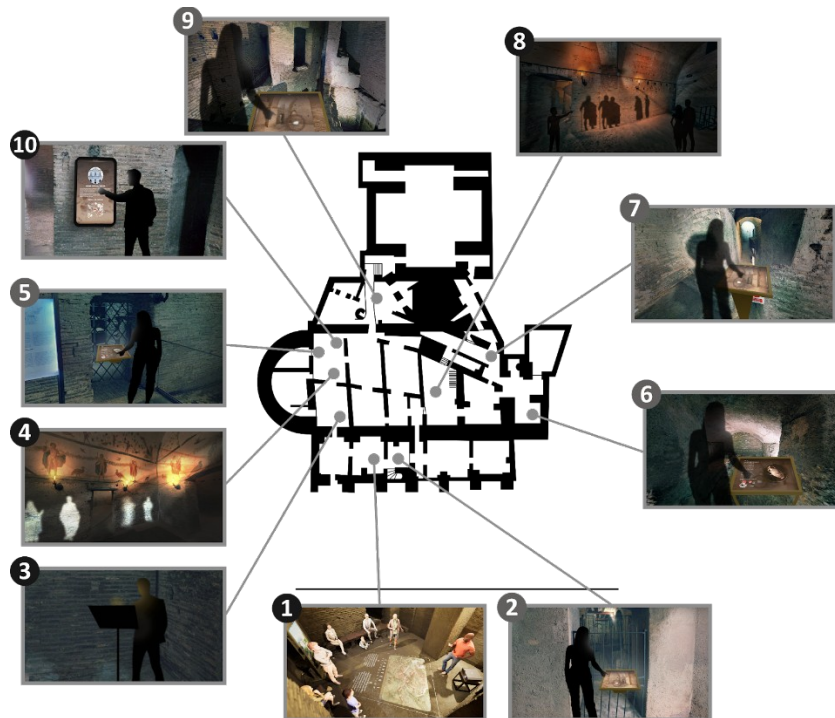
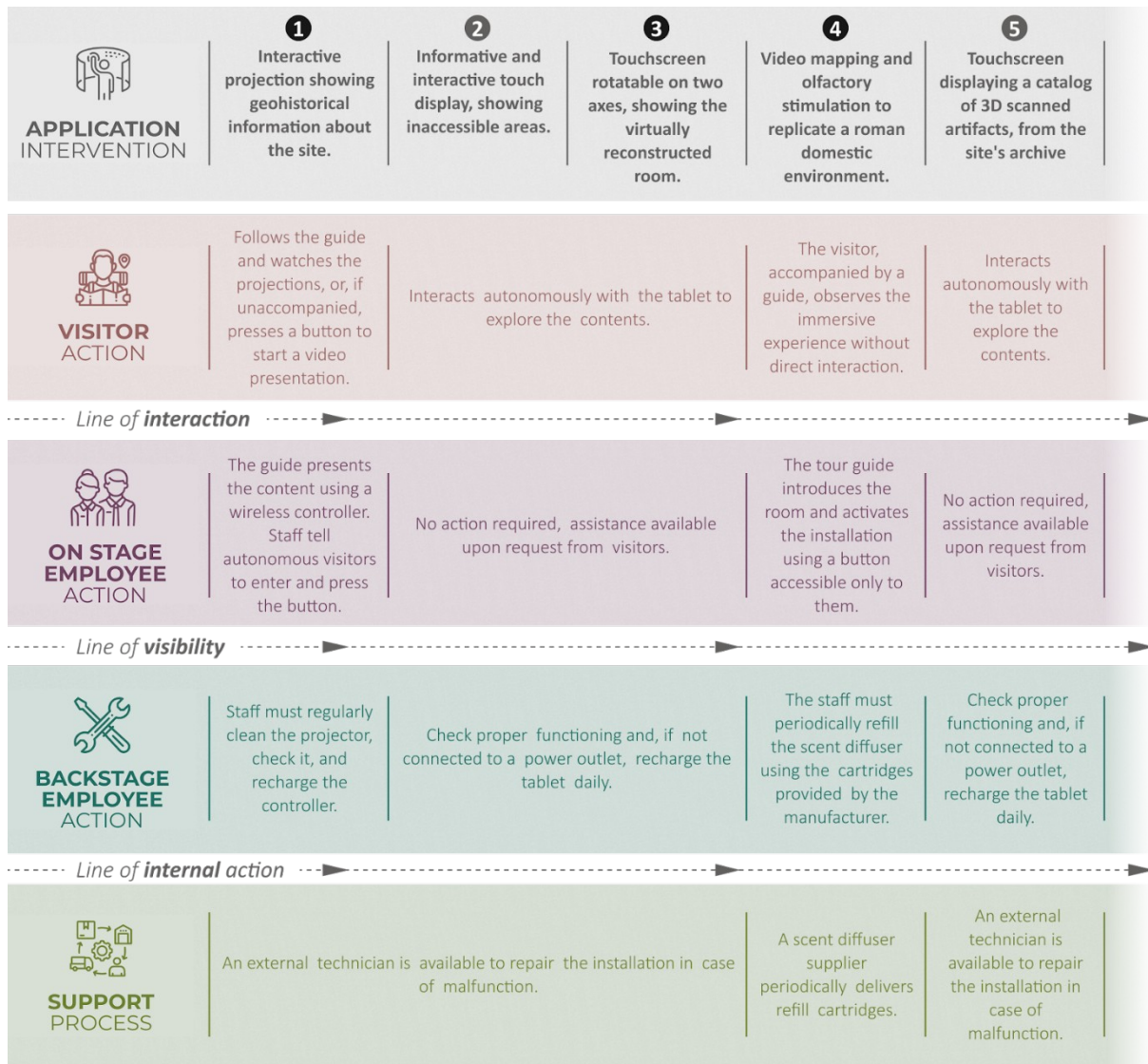


Figure 7 Placement of installation concepts in the CRC site.

The ten interventions were classified as primary or secondary: primary installations are indicated by black numbered circles, while secondary ones appear in grey. This distinction reflects the importance of the content conveyed, separating elements that communicate the site's core cultural values from those that play a complementary role within the narrative. The experiential offer also varies according to whether the visit is autonomous or guided, as some installations are accessible only with guide assistance.

3.3.1 Service blueprint

In the Service Blueprint (Bitner et al., 2008), the installations designed for each area of the archaeological site are briefly described, outlining visitor actions in relation to staff actions as defined by the *line of interaction* and the *line of visibility*, which distinguishes frontstage from backstage activities required to keep the service operational (see Figure 8). This model proves useful not only for describing the user experience for which the service is intended, but also for representing the experience of the managers responsible for maintaining the service's functionality.



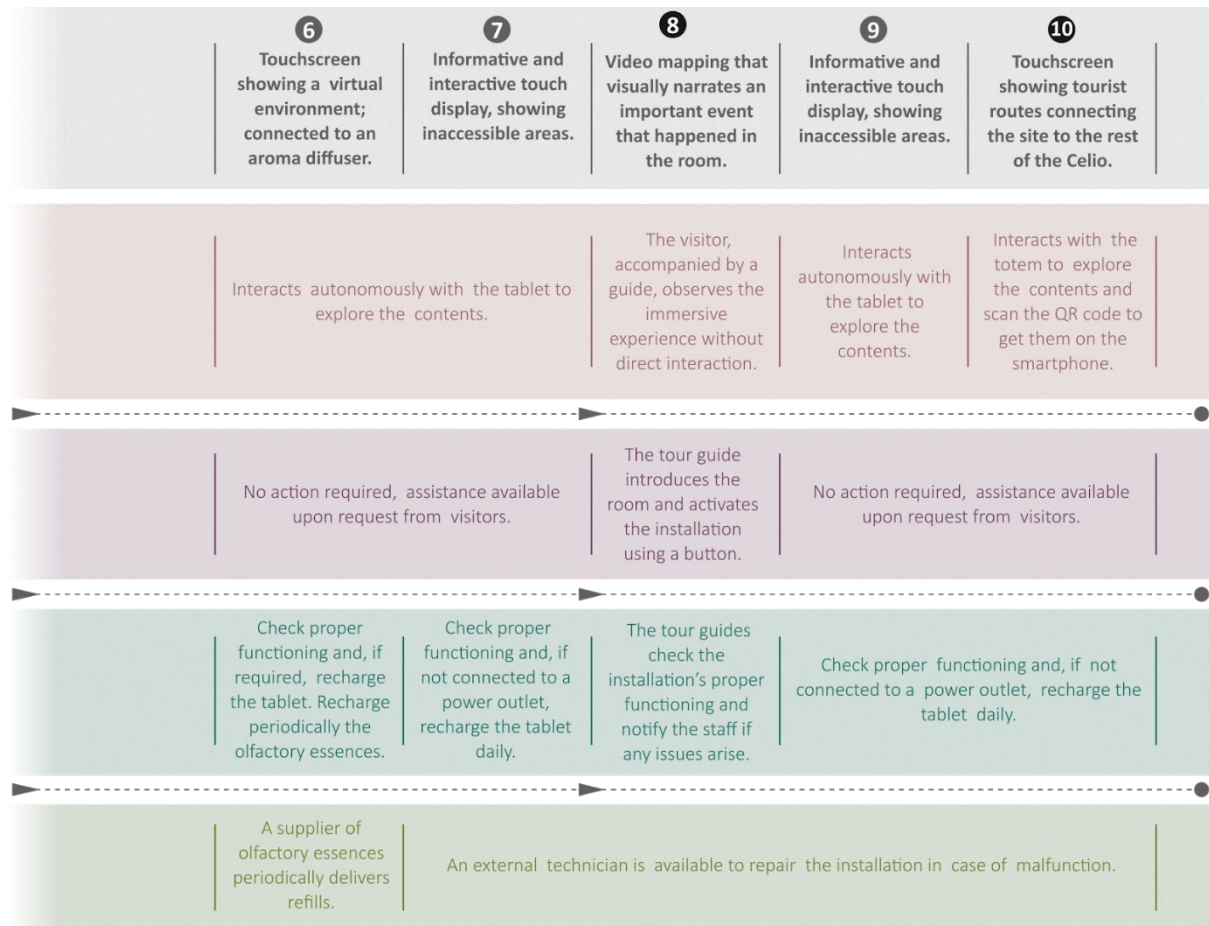


Figure 8 Service Blueprint of the experience concept.

The selection of the installations and their contents was guided by several factors. First, the site's physical and managerial constraints required non-invasive, low-maintenance solutions compatible with the sensitivity of heritage spaces (Gasparotto & Dall'Oso, 2024), given the limited human and financial resources available for long-term management. For this reason, the Service Blueprint was used to highlight the high level of autonomy required of the installations and the minimal staff effort needed to operate them.

A second factor concerned visitor engagement. Unlike most case studies reviewed (Arena et al., 2025), where XR technologies function as isolated experiences, the intervention adopts a coherent narrative framework that interconnects all installations into a unified experiential journey. This coherence applies to storytelling, interaction modes, and digital content engagement, ensuring that each technological component meaningfully contributes to a continuous, contextually grounded narrative rather than acting as a stand-alone attraction.

A third factor involved the role of tour guides. To ensure sustainability and stakeholder benefit, the installations were designed to support, rather than replace, guide-led mediation by providing multimedia tools that enrich explanations and visitor interaction.

3.3.2 Visitor journey post intervention

The post-intervention visitor journey (see Figure 9) summarizes the technological implementations introduced in each room and highlights which installations are accessible only during guided visits, allowing the site to diversify the experience according to the visit type.

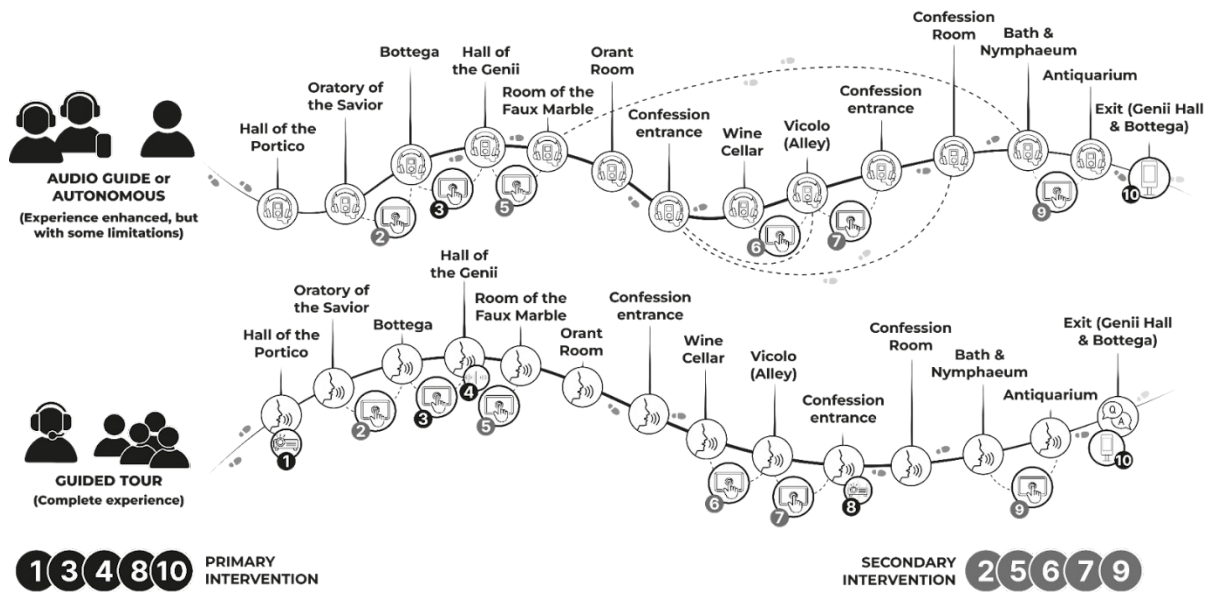


Figure 9 Visitor journey post intervention.

3.3.3 Narrative-driven XR experience diagram

To support the design of the narrative dimension, a hypothetical qualitative diagram, the Narrative-Driven XR Experience Diagram (NDXRE), was developed during concept definition (see Figure 10). It visualizes the expected level of visitor engagement along the journey based on the typology and spatial distribution of the installations. As a design hypothesis, it aims to balance cognitive load and sensory stimulation to foster optimal engagement, satisfaction, and learning effectiveness.

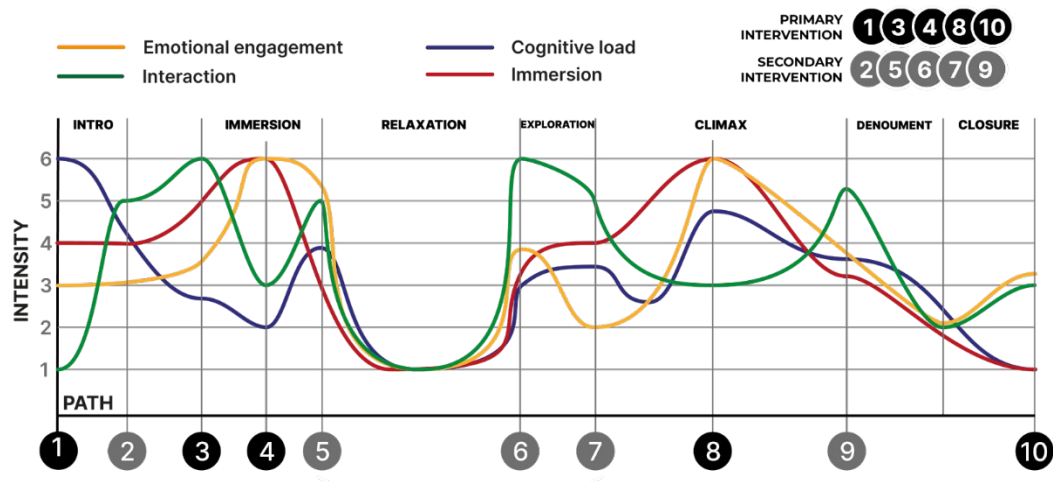


Figure 10 Narrative-driven XR experience diagram for guided tours in CRC.

Desk research on XR technologies (Arena et al., 2025) has shown that user satisfaction depends on factors such as:

- **Immersion**, or the sense of presence within virtual or augmented environments (Makransky et al., 2021);
- **Interaction**, namely the user's ability to actively engage with digital elements, enhancing agency and participation (De Paolis et al., 2023);
- **Engagement**, understood as cognitive, emotional, and behavioral involvement (Wang et al., 2024); narrative, which provides coherence, meaning, and continuity through a structured storyline (Hammady et al., 2020);
- **Cognitive load**, the mental effort required to process and interact with content, which must remain optimal to avoid overload and reduced satisfaction (Makransky et al., 2021).

Balancing these stimuli throughout the visit is therefore essential to sustaining attention (O'Dwyer et al., 2021; Puig et al., 2020). To this end, the intervention employs a variety of devices with differing interaction mechanics, levels of immersivity, and content types, ensuring a more harmonious and rewarding visitor experience.

The NDXRE diagram (see Figure 10) positions the XR installations along the X-axis, organised temporally and sequentially. On the Y-axis, it reports the qualitative values assigned to four parameters associated with each installation. These values derive from the type of technology adopted, the nature of the content, and the selected modes of communication.

The sequence underpinning the diagram draws on *Gustav Freytag's five-stage narrative arc* (see Figure 11). Freytag's pyramid remains a widely used narrative model across literature,

cinema, and contemporary media, making it an effective reference for structuring the experiential progression of the visit.

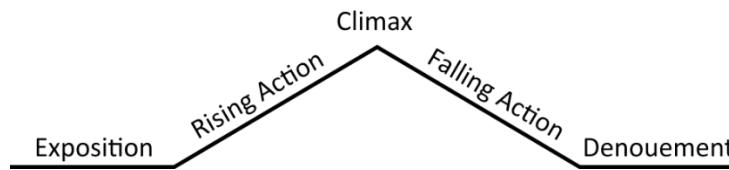


Figure 11 Gustav Freytag's five-stage narrative arc.

In the NDXRE Diagram, Freytag's arc is expanded into seven phases that structure the experiential progression:

- The **introductory/Exposition phase** relies on visitors' initial attentional peak to deliver essential contextual and historical information;
- The **immersion/ Rising Action phase** increases engagement through narrative and sensory stimuli that foster emotional connection;
- The **relaxation** phase reduces cognitive load through lighter, optional interactions;
- The **exploration** phase encourages visitors to investigate the environment freely and interact with different installations autonomously, supporting curiosity-driven discovery and personal engagement.
- The **climax** marks the peak of attention and affective involvement, here associated with the *Confessio* room and his peculiar anecdote;
- The **denouement**, naturally declines the engagement as visitors move through visually rich spaces where additional stimuli add limited value;
- The **closure** phase supports reflection and meaning-making, offering opportunities to extend the experience beyond the site through related services or local activities.

The NDXRE Diagram should not be regarded as a rigid framework for structuring the visitor experience, as multiple factors influence the decision to integrate, or exclude, specific installations along the route. Rather, it serves as a design support tool that outlines the overall trajectory of the experience and highlights the interrelations among individual interventions. This makes it possible to assess whether the sequence of installations ensures a dynamically engaging experience throughout the visit, or whether additional or fewer technological stimuli may be required. The following diagram (see Figure 12) illustrates the experience of the independent visitor, who cannot use certain installations.

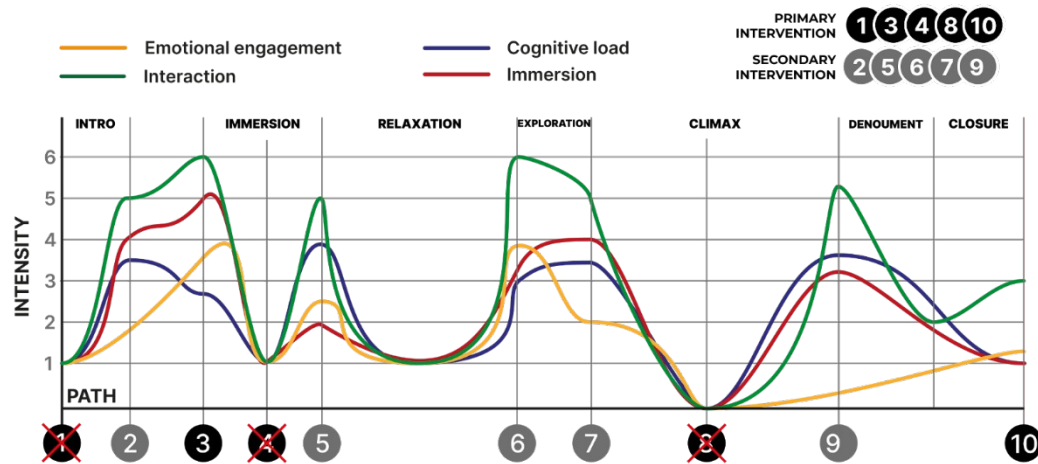


Figure 12 Narrative-Driven XR Experience Diagram for autonomous visitors in CRC.

In this case, engagement levels are lower than in guided group visits, showing how the site's offer can be calibrated by visit type and ticket category. The comparison between the two diagrams further confirms the NDXRE's modular and flexible nature, supporting adaptable experience design rather than imposing a fixed structure.

3.4 Phase IV: Deliver

The project is currently positioned between the Develop and Deliver phases. Several installations have been fully designed and prototyped, both physically and digitally, and are undergoing informal testing to refine their UI and UX. A subsequent, more structured evaluation with actual CRC visitors will follow, incorporating quantitative methods such as user testing, surveys, and A/B testing to assess effectiveness and guide further iterations.

Once the experimental phase and pilot evaluation are completed, the project will produce guidelines, toolkits, and modular "plug-and-play" systems to support scalability. These resources will enable other archaeological sites, particularly those with limited budgets, to adopt adaptable, low-cost digital solutions using preconfigured models suited to varied spatial and cultural contexts.

4 Discussion

The project conducted at the CRC site illustrates how applying SD methodologies to the redevelopment of archaeological contexts can provide an operational framework capable of reconciling often divergent priorities: conservation, management, visitor experience, and technological sustainability. The use of tools such as stakeholder maps, journey maps, service blueprints, and user personas supported a holistic understanding of the context, facilitated coordination within a heterogeneous team, and reduced the risk of fragmented or inconsistent interventions. These tools also contributed to clearer communication, helping align stakeholder interests and secure broad agreement on the project direction.

At the same time, the work exposed several limitations inherent in the instruments employed: the visual models used neither incorporate quantitative criteria nor enable objective assessment of narrative effectiveness or the impact of installations without appropriate prototyping and testing. As a result, they cannot guarantee user satisfaction or ensure the long-term viability of the intervention prior to real-world validation.

The visual models could be supported by experimental phases to empirically verify whether the design hypothesis meets the expected outcomes. Furthermore, for future interventions in other CHS, the models and the general approach may need to be enriched with more substantial quantitative data and scientific methods, making them more predictive and scalable in real-world contexts, increasing their reliability, and reducing the risk of project failure during the *delivery* phase.

The NDXRE Diagram, developed as an attempt to depict visitor engagement and narrative coherence across the spatial experience, introduced a rare approach within SD for CH: an explicit narrative structure supporting the design of XR content. This perspective helps mitigate cognitive overload, manage attention peaks, and construct a coherent trajectory throughout the visit. Although still experimental and requiring further validation, the model suggests a promising direction for extending SD toolkits toward the design of spatially distributed narrative experiences in heritage contexts.

Overall, the CRC project underscores the need to approach the digital transformation of CHS as a systemic process. Rather than focusing primarily on deploying the latest XR technologies, at the risk of shifting visitor attention toward the tool rather than the content, the design effort should center on the material to be conveyed and on a storytelling strategy that spans the entire visitor journey, from entry to exit.

Although derived from a specific case study, these observations reflect broader challenges frequently encountered in CHS undergoing digital transformation. In this sense, the research suggests that the integration of SD and DT approaches can provide a valuable methodological framework for managing complexity, aligning interdisciplinary expertise, and supporting more sustainable and context-sensitive digital interventions.

Finally, the project confirms that for redevelopment initiatives in CH settings, interdisciplinary teams bringing together designers, conservators, engineers, and site managers, guided by a SD approach, is a good practice to achieve solutions that are both realistic and sustainable over the long term.

5 Conclusion & future work

The research introduced a participatory SD approach for mediating the post-digital transformation of CHS, fostering sustainable and innovation within archaeological contexts. By focusing on the CRC, the study demonstrated a methodology framed by RtD and the Double Diamond model to address systemic challenges by CHS. The project illustrates how CHS are embracing digital transformation and how this shift can enhance their service across multiple dimensions. By delivering meaningful experiences and developing integrated services, CHS can embrace digital transformation not merely as a technological upgrade but as an opportunity to rethink the services they provide to visitors and the broader urban context.

The resulting interventions in CRC, based on XR and narrative-driven design, propose a model for reinterpreting experiences in archaeological sites. Rather than introducing technology as an isolated attraction, the project frames digital tools as components of a coherent and integrated visitor journey, in which different installations contribute to a unified storytelling strategy.

The next phase of the project will involve testing several of the developed installations directly within the CRC site. This stage will allow the collection of more robust quantitative data and the active involvement of key stakeholders, including visitors and tourist guides. The aim is to validate the hypothesis that certain technological devices are preferred over others when presenting the same content, using methods such as A/B testing. The insights gathered during this phase, both from user preferences and from observing how staff manage and support digital interactions, will inform the development of more precise guidelines and refined toolkits, clarifying the actual usefulness of the design approach and its potential replicability in similar heritage contexts. Following this experimental phase, the applications and physical prototypes developed during the project will be released as open-source resources to expand possible applications and enable further development by other researchers.

More broadly, the research highlights the importance of supporting digital transformation in CH through design approaches that prioritize narrative coherence, usability, and contextual integration rather than technological novelty alone. It suggests that the development of digital experiences should focus primarily on the quality of content and on the usability of interfaces, considering the needs and capabilities of both visitors and site operators.

Finally, the study emphasizes the value of approaching the visitor experience as a continuous journey rather than as a set of isolated installations. This systemic perspective can help reduce the risk of technological obsolescence and abandonment, a common issue in heritage digitalization projects that fail to adequately consider the operational constraints and long-term sustainability of the site.

Through iterative processes such as DT and fast prototyping, CH contexts can experiment with alternative solutions and allow for controlled or “calculated” failures during the development phase. This approach enables institutions to test design hypotheses, learn from intermediate outcomes, and progressively refine interventions before large-scale implementation, ultimately supporting the development of more sustainable solutions over time.

In this sense, the service designer emerges as a key mediator within interdisciplinary teams, leveraging SD and DT practices to support more resilient and context-sensitive digital interventions in CHS.

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