



Original Research

Rethinking Cultural Heritage through the Design Creativity Lens: Understanding the Dimension of the Ancient and the Knowledge of New Technological Realities

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Abstract: The increasing integration of media, digitalization, and communication technologies has profoundly changed human behavior within the built environment. The fusion of physical and digital domains has generated new hybrid spaces characterized by active, reactive, and interactive experiences. Individuals are no longer passive inhabitants but engaged virtual users. This shift significantly impacts exhibition design, particularly in museums and historical sites, fostering innovative approaches that enhance visitor participation and multisensory engagement. Exhibition design has evolved into a complex intersection of cultural and technological fields, amplifying its potential to communicate meaningfully with diverse audiences. However, traditional design skills and tools are no longer suitable to address the challenges posed by the interplay of tangible heritage and immaterial digital elements. The main design challenge is to manage the dualism between the tangible physical domain and the immaterial virtual domain, elevating the visiting experience of ancient cultural heritage to a more participatory and sensory-engaged level. This article explores how to balance material and immaterial elements in exhibition design, respecting the physical identity of historical places while promoting a more participatory and sensory-rich visitor experience. The discussion is grounded in a design project developed by students at the University of Rome La Sapienza, offering practical insights, applying a multidisciplinary design methodology, and opening avenues for further interdisciplinary research.

Keywords: Cultural Design, Cultural Heritage Experience, Heritage Re-Use, Hybrid Contest, Connections, User-Centered Design

Introduction

The use of technologies, particularly those of communication and information, within the places of our everyday life, such as domestic, work, and cultural spaces, has created an integration between the physical and digital domains. This has generated “different” contexts that can be defined as “hybrid and connected”: “hybrid” because they are a fusion of physical and digital methods and elements, and “connected” because a virtual network is created between users and places, in which the concept of time and physical space is eliminated (Farina et al. 2018). In such environments, the traditional utilitarian characteristics of space have transformed as users interact differently and redefine their expectations. Daily actions

change as they are carried out through continuously evolving devices, which are numerous and indispensable in importance and comparable to “digital prostheses.” Connectivity enables individuals to perform various tasks, from exchanging information to managing household items and bank accounts, holding business meetings and more (Farina et al. 2018).

In the realm of cultural heritage, this “hybrid and connected” dimension has been consolidated and is becoming increasingly prevalent. Indeed, in historical sites and museums, the use of the virtual began almost timidly during the internet revolution of the 1990s, primarily through the introduction of information portals providing basic general content. Today, it manifests itself in an exponential crescendo in various forms, levels, and technologies. The digital dimension has effectively transcended screens to merge with physical spaces, creating a “hybrid continuum.” A set of material and immaterial elements, extended and connected in time and space, have formed a “heritage continuum” (Lupo 2021), which indifferently inhabits the physical, immaterial, and hybrid dimensions.

This scenario of digital transformation has taken on multiple faces and names, ranging from the metaverse through physical reality to smart reality. All of this has led to profound changes in meaning and use in all those places designed for visits, such as museums, archaeological sites, and historical spaces in general. These simple static containers have become dynamic generators of immersive experiences and space-time access portals. In them, the visitor is no longer a passive spectator but becomes a virtual user to whom the pervasiveness of technologies allows for establishing an almost symbiotic relationship with the environment.

Within these spaces, the active participation of the individual has radically changed the design approach, orienting it toward a user-centered model (Norman 2013). This methodology, akin to the development of interfaces and devices, is extended to physical environments, conceived as “large communicating interfaces” that interact with the user-visitor. The design focus has, therefore, shifted from the static placement of artifacts in the environment according to their functionality to the centrality of the user experience to create interactive, adaptable, and sensitive environments. Exhibit design, in this context, has been the key discipline in the design of “hybrid and connected” environments for its ability to mediate between the individual and the context (Bollini and Borsotti 2016). Through an interdisciplinary approach that integrates design, technology, and cultural studies skills, exhibit design has begun to measure itself with the creation of experiential and immersive environments that in the past were intended for protection and conservation. In historic spaces, the project, which has become narration and experience of this, favors the narrative dimension (Dal Falco and Bonomi 2021; Bollini 2023), becoming an act of transcribing the memories and contents that these places embody. The designer finds themselves managing a dynamic flow of information, images, and interactions to enrich the visitor’s experience and promote a new way of cultural fruition.

This study is placed within the framework of research and practices related to Design for Cultural Heritage to investigate its design dimension through an in-depth reflection on the relationship between space, user, and object. One of the critical aspects that have emerged in the literature, now extensive and exhaustive on the subject, is the risk of reducing the project of cultural places to the triad “user-technologies-objects.” This neglects the fundamental role of the place itself and its influence on the experience. Often, cultural places are considered and equated to simple containers, similar to neutral “white boxes” to emphasize works of art (O’Doherty 2012), and therefore destined to be filled with physical or multimedia content. However, such places are not only exhibition spaces, but also a heritage to be enhanced, communicated, and reinterpreted.

This article is structured in two main parts that develop the themes from theoretical and practical perspectives. The first part, including a study and analysis of the reference contexts, explores the relationship between design and cultural heritage and its evolution following the disruptive advent of new technologies. The second part, which is operational, presents the experiences gained over five years within a design laboratory of the course of Design for Public Space at Sapienza University of Rome. This project involved students from the three-year design course, addressing issues related to cultural heritage and experiences to develop specific courses.

The purpose of this article is to provide a coherent interpretive framework for ongoing innovation processes, stimulating debate and reflection at both the theoretical-methodological and practical levels. This framework is based on critical rereading and analysis of case studies. Additionally, this contribution aims to share the achievements and disseminate the working model. The model has originality in the interdisciplinary approach adopted, aimed at interpreting and integrating historical, critical, and exhibition elements to create interactive spaces and contextualize the projects.

From Physical to Phygital

Cultural heritage environments, such as museums located in historical contexts, ancient buildings, and archaeological sites, are spaces with powerful physicality and high narrative potential. This qualifies them as “communication spaces.” These environments are repositories of memories, stories, and information layered over time, which can be discovered, interpreted, and communicated. The increasing integration of technologies, now deeply embedded in the fabric of physical reality (Vongsingthong and Smachat 2014), both through pervasive networks and devices, has significantly amplified the communicative capabilities of these spaces. Therefore, their contents are transmitted in innovative, dynamic, and interactive formats, including websites, smartphone applications, or virtual and augmented reality worlds.

The overlap and integration of material and digital elements have given rise to a scenario defined as *phygital*. This neologism, coined by the marketing agency Momentum in 2013, conceptualizes the fusion of the physical and the digital, to the extent that they do not simply complement each other but rather reinforce each other (Nofal et al. 2017). In the *phygital* context, physical space is viewed as an information system that communicates with users through various interfaces. Here, the modalities, accessibility forms, and experiences of cultural heritage are considered to change. Space becomes fluid, and the physical-analog world and the digital world converge and interact (Lupo 2021) in a kind of hybrid, interactive, and interconnected communication ecosystem (Bollini and Borsotti 2023).

Cultural heritage environments and the corresponding communication system have been transformed into a “*phygital heritage*” (Nofal et al. 2017). Information is disseminated through both physical and digital means simultaneously and identified as a continuum that extends from the fully real to the fully virtual environment, with augmented reality and augmented virtuality taking intermediate positions. The continuum scenario is made up of precise characteristics identified and described by Nofal et al. (2017). Accessibility, customizability, immersion, materialization, affordance, and situatedness are fundamental to designing spaces that effectively unite the physical and digital. Among these, “*situativity*” and “*affordance*” play crucial roles in the degree of integration and interdependence between the physical and digital domains. *Situativity* refers to the extent to which technology is dependent on its physical context, whereas *affordance* evaluates the extent to which physical features facilitate user interaction. These characteristics underscore the importance of the physical context as a critical point of connection with users.

Therefore, in a physical scenario, it is essential to consider the physical dimension, not just technological and IT advancements, during the design phase. In hybrid space, computer and electronic elements must be managed, calibrated, and interconnected with the design of physical elements to establish different degrees of materiality and immateriality within the continuum. Furthermore, the meaning and value inherent in the physical domain must also be taken into account.

Designing in the Physical Scenario: Hybrid Spaces

The concept of “*phygital*” has opened up the challenge of proximity to heritage, bringing people closer to it through a more direct and tangible connection between the continuum of heritage and the public. It favors a tangibilization of relationships (Lupo 2021). The importance of making the immaterial components explicit and experienceable is emphasized (Miano and Borsotti 2023), through the senses, primarily touch. This builds a dialectic between digital and real space. This interaction promotes experiential iteration guided by history and the humanization of technology, mediating experience with physical, cognitive, or virtual space. This gives rise to the need for mixed-mode design, where “it is necessary to

design a ‘hybrid materiality’” through advanced human-computer interaction approaches, such as embodied or material interaction (Galani and Kidd 2020, 298). In this context, it is worth distinguishing between the broader phygital scenario, a fusion of physical and digital realms at the environmental or spatial scale, and the concept of hybrid, which refers specifically to physical objects or elements designed to integrate digital or virtual functionalities. Hybrid artifacts are tangible entities that embody a combination of material presence and digital capabilities, enabling enriched user interaction through multimodal experiences. Transforming a space from physical to hybrid requires a coordinated design of all elements, where physical and digital devices are configured as a whole. Both the real space and the digital overlay work together as part of a narrative or superordinate activity (Hornecker and Ciolfi 2019).

This creates a hybrid connected heritage composed of augmented and geolocalized information and content that overlap and complement materials, objects, and places. This hybrid scenario, characterized by interactivity, immersion, and accessibility, presents new perspectives for the enhancement of heritage. However, it requires a meticulous and interdisciplinary design approach.

Despite the evident benefits of digitization, important critiques and ethical concerns surround its impact on cultural heritage. Ethical considerations are paramount in digital heritage projects. Digital reproduction and reinterpretation carry significant responsibilities related to authenticity, respect for the original site’s integrity, and sensitivity towards cultural meanings and stakeholder communities. Designers must navigate these concerns carefully to avoid misrepresentation, cultural appropriation, or dilution of the site’s significance, ensuring that digital interventions honor both tangible and intangible heritage values (Rouhani 2023). From this new reality emerges the understanding of how fundamental it is for projects to consider not only technological innovations but above all the symbolic, narrative, and contextual dimensions of cultural places. Effective design must include material and immaterial elements, creating a coherent narrative that enhances both the identity of the place and the user experience.

Interaction, Tangibility, and Physical Environment

Recently, numerous applications and experiments have explored the integration of physical and digital domains within the realm of cultural heritage. The interventions have been designed to enhance the communication capabilities of the location and improve the overall visitor experience. Particular technologies have been developed and applied to promote different degrees of interaction between the individual and the surrounding environment, to achieve complete integration between technology, the materiality of objects, and the physicality of the visit experience (Petrelli and Roberts 2023).

The notion of interaction holds great significance in comprehending the transition from a conventional, often contemplative museology to participatory museology. As argued by Bannon et al. (2005) and Petrelli et al. (2023), the integration of technology, the materiality of objects, and the physicality of the experience allow visitors to engage more deeply with heritage through dynamics of “experiential proximity.” Through this approach, the user acquires an increasingly active role within cultural spaces, thanks to the possibility of interacting directly with the environment. This includes touching objects, manipulating tangible elements, or simply moving in the physical space. The concept of interaction, developed within interaction design and human-computer interaction, has been the key to overcoming the challenge of proximity between heritage and visitors (Lupo 2021), making interactions increasingly natural and similar to those people carry out in the real world.

In the current literature, human-computer interaction introduces the concept of tangible interaction (Duranti et al. 2024) when visitors interact, manipulate objects, or perform bodily gestures within the visited place. Specifically, such interactions can be categorized into two categories: first-level tangible interactions, which are based on the use of touch gestures and the physicality of surfaces, and embodied interactions, which involve the entire body through movement. The latter approach transforms the exhibition into a performative setting, resulting in an experiential rewriting of time and space (Pallasmaa 2009). Through these modalities, a transition occurs from the tangible value of the place, its material reality, to its intangible value, linked to the symbolic and archetypal identity that the place expresses (Duranti et al. 2016). Both these types of interaction, tangible and embodied, require the physical presence of the user in the space and that the environments be navigable. However, while not excluding each other, they can be expressed in distinct design configurations.

In the case of embedded interactions (Duranti et al. 2016), technology is integrated into artifacts or physical structures of the place, enhancing and amplifying their communicative functions. Examples include digital displays, proximity sensors, and smart objects. These devices are designed to create a multisensory experience, as in the Piccolo Museo del Diario (2014) in Pieve Santo Stefano (Arezzo), Italy. Designed by the Dotdotdot studio and conceived as a multisensory and interactive path aimed at narrating autobiographical memories of ordinary individuals, it was one of the initial examples of the amalgamation of the two domains. The installation is a large wall cabinet placed inside a historical environment, similar to a technological object. It is integrated with audio-video systems, sensors, microcontrollers, lights, and computers. The interaction occurs through the opening of drawers and doors, combining mechanical and digital components to create an immersive experience wherein one can listen to memories and visualize faces.



Figure 1: Dotdotdot, Piccolo Museo del diario, Pieve Santo Stefano, Arezzo, Italy, 2014.
“Il fruscio degli altri” [The Rustling of Others], Room Dedicated to the Archive
Source: Photo by @Alberto Ferrero

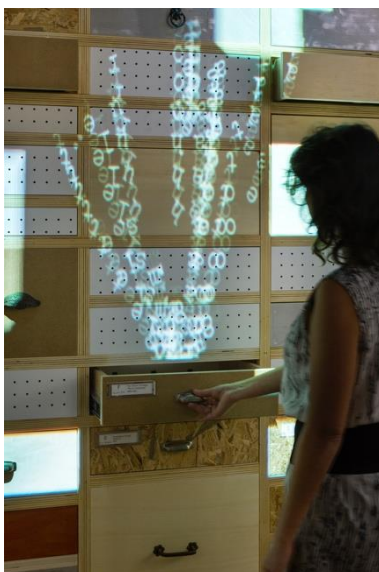


Figure 2: Detail of the Large Wall Cabinet
Dotdotdot, Piccolo Museo del diario, Pieve Santo Stefano, Arezzo, Italy, 2014
Source: Photo by @Alberto Ferrero

Another example is the Aboca Museum Experience, also designed by the Dotdotdot studio, at the Renaissance structure, the Palazzo Bourbon del Monte in Sansepolcro (Arezzo) (Dotdotdot 2024). The entire installation develops along a series of rooms, with the insertion of large, self-supporting wooden structures in compliance with the ancient context constrained by the fine arts. In these elements, designed as large tactile walls and consoles, visitors interact, by activating sensors and receiving information. At the end of the path, the visitor can leave a message to contribute to the growth of an evocative “vegetal installation,” to reiterate the connection between man and the living system (Dellamotta 2019).



Figure 3: Dotdotdot, Aboca Experience, San Sepolcro, Arezzo, Italy. 2020

Source: Photo by @Filippo Bramberghi



Figure 4: Dotdotdot, Aboca Experience, San Sepolcro, Arezzo, Italy. 2020

Source: Photo by @Filippo Bramberghi

In the case of embodied interactions, where gesture and body movement are considered activators of the sensitive environment (Duranti et al. 2016), using augmented or virtual reality technologies, there is an overlap between the virtual and physical domains. The result is an

immersive environment that is perceptible through 3D viewers or interactive screens and an experience that directly affects the user's perception of space. A representative example of this methodology, where Studio Azzurro was the precursor, is found in the works of the studio, where the body becomes an active agent in the narration and enjoyment of cultural heritage.

The immersive reality technique enables the use of digital viewers to visualize locations in their entirety and to physically move within them, allowing visitors to immerse themselves in the historical contexts of archaeological sites. An immersive reality application with 360-degree 3D reconstruction was developed by the CNR in 2018 for the Museo delle Terme di Diocleziano in Rome. This application, *Le Terme con gli occhi di Diocleziano*, allowed users to better understand the architecture of the complex due to the perfect superposition between real and virtual vision (Caruso 2021). The London Mithraeum Project is a significant museum intervention in one of the United Kingdom's most significant archaeological sites. The project was completed in 2017 by Studio Joseph on the site corresponding to the ancient location of the temple of Mithras, seven meters below street level. The New York studio Local Project has employed advanced theatrical and holographic technologies for the virtual reconstruction of the ancient Roman temple, which dates back to the Roman era of London (Block 2017). These technologies recreate the temple's structure through the interplay of light and fog, providing visitors with an immersive experience that showcases the archaeological site from a three-dimensional perspective. The superimposition of digital images onto the physical reality of the site offers new ways of narrating and interpreting places, promoting a deeper understanding of the historical and cultural heritage.

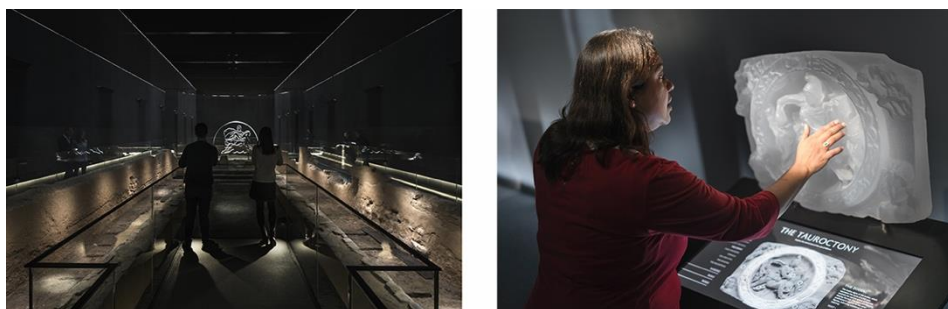


Figure 5a. 5b: Local Project, London Mithraeum, 2017

Source: Photo by @ Local Project

In the HoloMuseum at Castel del Monte (Puglia, Italy), the path is integrated with Microsoft Cloud Computing, artificial intelligence, and mixed reality technologies, which enhance and amplify the narrative and exhibition capacity of the exhibition (Microsoft 2021). In these instances, the visitor's engagement and perception of the space differs from the traditional models. The use of cultural spaces is shifting from a passive to a participatory dimension, transforming the visitor into an active participant in the cognitive process of the

place, making them the protagonist. This multidimensional approach enhances the sensory experience and makes cultural heritage places into highly communicative spaces.

The question is which design dimension is appropriate for managing the complexity of contemporary cultural contexts. As Fulvio Irace (2014) argues, the implementation and experimentation of various new technologies have resulted in a domino effect that has impacted the design, enjoyment, and perception of places, necessitating a new approach to design. Traditional skills and tools, which resided in the curator-architect relationship, design, and physical structures, are no longer sufficient. The challenge is to define a multidisciplinary and coordinated design dimension to create equipment suited to the new communication needs while also respecting the historical identity of these places. These places are considered to be lived and shared, and no longer just preserved and conserved.

Design and Cultural Heritage: An Integrative Approach

In this contemporary scenario, where the authority of design as an applicative and interpretative tool of cultural heritage is now affirmed and consolidated (Lupo 2021, 187), the educational and design experience undertaken fits into this context. Design is regarded as the most suitable tool for managing the new dimension, serving as a link between individual and context, as well as a means of cultural mediation. We were interested in exploring a new approach to design that merges design principles with cultural heritage. The design experience aims to enhance design creativity, applying it to a field traditionally associated with history and conservation. Adopting a holistic approach that supports the creative reuse of heritage (Lupo 2019), it seeks to rethink and redefine how we interact with cultural heritage.

Initially, the association between design and cultural heritage appeared almost paradoxical. Design has traditionally been associated with serial production, while cultural heritage has been linked to the preservation of the ancient and the significance of uniqueness. This relationship is akin to the “paradoxical taste of the oxymoron” (Irace 2014). Over time, however, the two worlds of design and cultural heritage have become increasingly closer due to the profound changes they have experienced. Cultural heritage has evolved into a broader concept of cultural heritage, defined by UNESCO as a set of material and immaterial goods, to be experienced, shared, and transmitted, thereby generating socialization and culture. This transformation is reflected in the modern museum’s changing role, which increasingly focuses on visitor involvement, combining educational goals with an engaging and intelligent experience (Germak et al. 2017). At the same time, design, applying its specific skills to the service of the experience of visitors and cultural institutions, has begun to deal with the enhancement of cultural heritage. It has introduced new processes and operational techniques into an increasingly immersive, experiential, and performative context.

translating the activities of protection, management, and enhancement into concrete project actions (Lupo 2019).

A further element of proximity between the two worlds has been the advent of digital technologies and new methods of communication in the field of cultural heritage. This has made design, which has consistently served as a conduit between technological advancement and individuals (Antonelli et al. 2008), a tool capable of translating innovations into products, services, and experiences (Tufarelli 2022). This capability is amplified and strengthened by its human-centric approach, providing solutions for the design of new hybrid contexts that enable increasingly active user participation and more participatory experiences for the public. Design can play a crucial role in transforming cultural spaces, reinventing not only their use but also the experience of visiting them. The design experimentation that is the subject of this analysis fits into this framework, which aims to explore new synergies between design and cultural heritage. Through an integrated approach, the goal is to create cultural experiences that transcend traditional boundaries, promoting more inclusive, participatory, and future-oriented forms of fruition.

Research and its Objectives

The research objective proposed as a macro-objective is to introduce the students of the Triennale di Design to the themes related to cultural heritage and cultural experience, dedicating specific teachings and courses to this topic. The aim is to explore a new approach to project-based teaching, one that combines an understanding of both the ancient and cutting-edge technological realities, integrating the relevant skills into the design process. In the project, the components “Heritage and Technologies” are not treated as a simple addition, but as an opportunity to develop a culture of integration between the two elements, where the materiality of history remains the protagonist (Irace 2014). This educational model seeks to leverage two types of heritage: a more material one linked to the spaces of history that need to be equipped, and an immaterial one tied to the meaning of places, which can be reinterpreted and transmitted to a participatory user. By adopting a human-centric design approach that encompasses contexts, artifacts, and technologies, it becomes possible to reimagine the cultural experience, transforming it into a hybrid and participatory dimension. A training model has been developed that explores the appropriate tools for managing the hybrid context. The project is based on the material and immaterial dimensions of the place: the physical dimension, which is tangible, perceptible, and walkable, and its immaterial value, which encompasses its historical, artistic, and cultural significance. Both dimensions are to be conveyed and shared through innovative methods, enabled by the potential offered by new technologies.

The Context of the Experimentation

The research was conducted within the Design Laboratory in the second year of the Degree Course in Design at Sapienza University of Rome, in collaboration with the Soprintendenza Speciale di Roma, Archeologia Belle Arti e Paesaggio di Roma (Special Superintendence of Archaeology, Fine Arts, and Landscape). This took the form of an experimental design activity, wherein design students were tasked with reimagining the experience of visiting historical sites through the creation and arrangement of lightweight, contextually relevant installations. These installations were conceived as interfaces between the user and the place.

The design experimentation, conducted over five years (from 2018 to 2023), developed within museum contexts. The project involved two Roman historical sites: an internal space, the Sala delle Olearie Papali of the Museo Nazionale delle Terme di Diocleziano, and an external space, the Comprensorio Archeologico di Santa Croce in Gerusalemme. Both sites in Rome were selected due to their exceptional historical significance and their remarkable capability to communicate cultural narratives and preserve historical memories. The transformational stratifications that have followed one another over time have offered a visual story rich in meaning. These qualities offered the opportunity to explore new narrative possibilities and transmit cultural heritage through the languages of design and technology.



Figure 7: Sala delle Olearie Papali of the National Roman Museum of the Terme di Diocleziano in Roma, Italy; View of the Roman Cistern

Source: Photo by Farina



Figure 8: Sala delle Olearie Papali of the National Roman Museum of the Terme di Diocleziano in Roma, Italy
Source: Photo by Farina



Figures 9 and 10: Archaeological Complex of Santa Croce in Gerusalemme, Rome, Italy
Source: Photo by Farina

The methodological approach involved a path divided into three work phases: “Inspiration and Knowledge,” “Artefacts Project,” and “Activation: Insertion and Verification.” The first phase, Inspiration and Knowledge, focused on understanding the place through a process of direct exploration. The objective was twofold: to define a visual concept consistent with the place and a mapping of the needs of both the site and the stakeholders.

A personal visit to the site initiated the process of direct knowledge. Observations, impressions, and sensations were collected and displayed through sketches, photos, and notes, along with the gathering of specific data related to the place. Direct contact with the site allowed us to understand the essence and meaning of the place, thus identifying its *genius loci*, a central element to be enhanced and transmitted in the project. Simultaneously, a qualitative data collection phase was conducted. Meetings were held with representatives of the superintendency, involving a collaborative co-design process to map their specific needs within the space. In contrast, site visitors participated through simple and informal interviews aimed at gathering feedback rather than actively co-designing. This represents a light or indirect co-design approach, where visitor input was collected after the initial concept development and used primarily to refine design ideas. In particular, the archaeologists of the superintendence, in a guided tour of the site, presented its history and highlighted its constraints, critical issues, and required uses. The interaction with the public, on the other hand, helped gather expectations and preferences through the interview technique, a series of open-ended, semi-structured interviews, based on age and user categories. The questionnaires focused on three key areas: expectations before the visit, activities they would have liked to perform on-site, and any shortcomings or obstacles encountered during the visit. The interview protocol was not standardized; however, recurring themes emerged, such as the desire for: playful and educational spaces for children, rest areas with shade and seating, interactive and accessible information tools, opportunities for personal reflection and connection with the historical atmosphere. Visitor responses were also spatially mapped through planimetric heatmaps, allowing for the identification of critical or opportunity zones within the site. This visual representation of qualitative data supported site-specific refinements in the artifact design phase. These findings were synthesized into graphic visualizations and discussed collectively during the design workshops.

Insights gained from these sessions informed key design decisions, such as the inclusion of playful features for children, social and rest areas, and study areas. However, it is important to note that this data collection was exploratory in nature, rather than systematic. No standardized survey instruments or large-scale empirical testing methods were applied at this stage. This limitation points to the need for future research to implement more rigorous empirical evaluation methodologies, such as structured user testing, and pre/post-visit questionnaires, validate and refine the proposed designs.

The second phase, the Artifact Project, focused on translating the collected data into concrete projects, with the transition from the idea, translated in a visual concept, to the

form. The forms, technologies, and systems suitable for expressing and describing the place to the user are studied. The phase is devoted to the conception and design of hybrid systems, comprising revisited traditional elements or light structures equipped with diverse technologies, ranging from simple bar codes to sensors. The equipment and the entire system were designed to stimulate a human-artifact interaction, in compliance with the constraints of cultural heritage, non-invasive and removable, to strengthen the identity of the place and communicate its history through advanced devices. Although not explicitly addressed in the experimentation, at this stage universal design principles, widely adopted in interaction design and ergonomics, could serve as a valuable framework to ensure accessibility and usability for a wide range of users.

The artworks that result from the process have certain key characteristics: contextualization, formal coherence, and compliance with the design constraints. The system is defined by a cohesive visual and material language that aligns with the needs of the studied location. The imagery is influenced by themes unique to the area examined. As lightweight artifacts designed as portable structures, they interact harmoniously with the environment without altering their contextual integrity.

The third final phase, Activation: Insertion and Verification, focused on the general design of the place through the integration of artifacts into the space and the creation of a coherent system of relationships between material elements and information. This system evolved into a functional network that was designed to initiate a cognitive and fruition experience that, through visual and conceptual connections, redefines the place and prepares it for novel functions. The generated network, composed of the designed elements, overlapped the site as an interpretative layer, outlining axes, paths, pauses, rest points, and perspectives. This made the site suitable for a broad range of uses, including exhibitions, guided tours, recreational activities, and educational events, while enhancing its interpretative and experiential value.

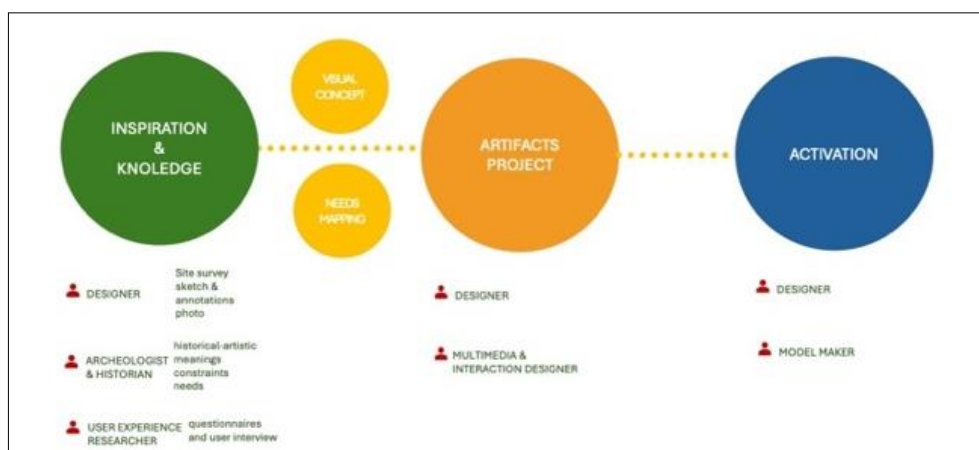


Figure 11: Work Phases of the Methodological Approach

The Results: Design, Ideas, and Projects

Over the course of a five-year educational experiment involving the students of Sapienza, more than seventy design proposals were developed for the two sites. These outcomes span a spectrum of interventions situated at the intersection of installation art and exhibition design. The proposed design features consist primarily of equipped pathways aimed at enriching the cultural visitor experience and accommodating the anticipated behaviors and needs of diverse user groups, including children, adolescents, scholars, and older adults. They are based on the principles of modularity, transformability, and disassemblability. Although universal design principles were not formally applied in the experimentation, the multisensory and inclusive nature of many proposals reflects an alignment with their core values. Future iterations of the design framework could integrate these principles more explicitly, thereby reinforcing its accessibility and inclusivity dimensions. The pathways systems include information devices, composite furnishings, and multifunctional microstructures. Specifically, the information systems aim to provide practical and accessible information, and offer a multisensory experience by using audio systems, tactile three-dimensional surfaces, and digital images. Each artifact was conceived as part of a broader system that establishes functional relationships within the site, codified through a formal and material language inspired by the surrounding environment.

The defining feature of all the elements is the integration of mechanical and digital interaction between users and artifacts, designed to foster a participatory and active experience within the space. The technologies within the artifacts were chosen based on the type of experience to be proposed: tactile, visual, and auditory. Technologies currently in use in museum spaces were applied, from the simplest and most economical, such as QR codes and wireless networks with Bluetooth transmitters, to the more elaborate ones, such as touch screens, proximity sensors, and projection systems.

The proposed systems combine cultural and recreational activities with the traditional visit to the site, thereby enriching the experience and extending the time visitors spent on-site. At the Complesso Archeologico di Santa Croce in Gerusalemme, for instance, several projects have provided areas for study, artistic activities, and children's play. Notably, indoor installations, such as those designed for the Sala delle Olearie Papali, demonstrated a higher degree of technological integration compared to their outdoor counterparts. The use of embedded lighting, projection systems, and small digital tablets proved particularly suited to the enclosed setting. Conversely, proposals for the open-air areas focused more on microstructures and pavilion-like elements, larger in scale but with a more limited technological component.

Design proposals were selected and evaluated based on criteria including contextual integration, the interplay between physical and virtual elements, and user interaction at both mechanical and digital levels.

Designs for the Complesso Archeologico of Santa Croce in Gerusalemme

Four proposals exemplify the application of concept-driven systems to site-specific spatial strategies; two categorized as equipped pathways and two as interactive installations.

Loop is an inclusive, low-tech, and lightweight modular system, composed of tubular steel components. It enables physical and sensory engagement through recreational features such as swings for children, seating for older users, and user-activated audio devices with embedded lighting. Its modularity allows flexible adaptation to user needs while maintaining a minimal presence within the archaeological landscape.

Fragmenta is a narrative-driven system that combines physical and digital components within an exhibition-style pathway. Built on a metallic grid structure, it includes traditional information panels, digital screens, and an audio systems for music and storytelling. Arranged along a color-coded path, the system draws inspiration from the ancient Roman Circus Varianus and fosters social interaction while guiding visitors through layered historical and symbolic narratives.

Portali creates an immersive experience based on the symbolic motion of the threshold between past and present. It features a sequence of arch-shaped vertical panels and observation platforms symbolizing a threshold between past and present. These metal structures incorporate polycarbonate surfaces with images, maps, interpretive texts, and embedded lighting. Interactive stations projected historical content, offering a multisensory experience blending physical and digital storytelling, mediating between imagination and the site's historical memory.

Declivio draws from a more experiential rather than didactic tradition, offering a “sensory and situated” engagement with the archaeological site. The project features four thematic “islands” positioned along a linear route, each offering a multi-sensory experience through sound, smell, and tactile materials referencing the site's history. Triangular floor markers, shaped like directional arrows, highlight key features and create a navigational rhythm throughout the space.



Figure 12: Complesso Archeologico di Santa Croce in Gerusalemme,
Design Project by Students: Maresi Federico e Elena Mihai, Chiara Foggia e Francesco Gasbarra, Giulia Iannone e Emma Fortinelli, Mariotti Caterina.
Source: Photo by Farina

Designs for the Sala delle Olearie Papali

Three additional proposals explore distinct typologies of multifunctional furnishings and projection-based systems integrated into the architectural setting

Amphora is a modular display system inspired by ancient Roman amphorae, traditionally used to store oil, grain, and water, all materials associated with the studied space. Its interactive totem combines mechanical and digital engagement and functions as both a tactile and visual interface that links historical materiality, cultural memory, and relational technologies. Adjustable lighting elements allow users to direct light beams interactively, offering an experience that is both educational and playful.

Fulcrum integrates physical and digital content within a formal design strategy that enhances the interpretation of the surrounding context. It consists of circular display structures inspired by the geometry of the room's cisterns. It integrates physical and digital content within a formal design strategy that enhances contextual interpretation. The structures echo the natural rotational movement of visitors, using lighting and screens to create an immersive learning environment.

Memory Drops aligns with site-specific installation practices, where technological intervention is minimal but emotionally potent. It consists of light-based devices that project patterns and ambient illumination into the cistern, producing dynamic visual effects. The

installation fosters a contemplative, immersive experience through the interplay of light, form, and cultural memory.



Figure 13: Sala delle Olearie Papali, Design Project by Students: Valentina Segnalini e Alexander Simonetti, Chiara Stefanori e Stefano Troilo, Simone Scafati e Claudio Zazza, Antonio Sasso Alessandro Mander e Valentina Stendardi, Rosati e Sebastiani, Giuseppe Manno e Angela Piazza.

Source: Photo by Farina

Design Principles

The developed projects demonstrate key principles, including technology as a medium rather than an end, contextual and perceptual sustainability, and narrative stratification. In all interventions, technology functions as a relational medium, a means to activate meaning, emotion, and user participation, rather than serving decorative or spectacular purposes. The structural lightness and modularity of many of the design elements reflect a continuous focus on the balance between intervention and context, ensuring reversibility and adopting a non-invasive design approach, an essential condition in sensitive archaeological environments.

Narrative is expressed in multi-layered forms: from explicit informational content (texts, screens, audio) to more atmospheric and symbolic experiences, as exemplified by Portali, Declivio, and Memory Drops. These demonstrate that design interventions can act as cultural interpretation tools, enabling users to engage with heritage beyond conventional didactic models. Arguably, the most significant contribution lies in the methodological dimension. These projects outline a scalable and adaptable design strategy, not confined to a specific site but applicable within a broader, systemic vision of heritage design—one in which public interaction becomes a central component of cultural heritage enhancement.

Based on the numerous artifacts and systems obtained, the research may have further future outputs to share with the design community. It can be defined as an evolving *abacus* (i.e., typological system) of recurring typologies of hybrid artifacts for environments and historical sites. Conceived with an object-oriented logic, these artifacts address both communicative and functional needs. The recurring typologies are, in fact, interactive information totems, multifunctional and multisensory microstructures, composite and equipped seating systems, interactive lighting systems, and sound artifacts.

These experiments may contribute to future developments in design for heritage contexts, representing a dynamic framework of hybrid artifacts designed for communication and environmental equipment within sensitive historical sites.

Conclusion

The results demonstrate how the collaboration among multiple disciplines, design, archaeology, and user experience, together with stakeholder involvement, and the use of light technologies, can enrich both the interpretative and functional value of archaeological contexts. The designed artifacts respected the identity of the places while activating new modes of cultural engagement and broadening the sites' accessibility to diverse audiences.

The Inspiration and Knowledge phase, guided by archaeologists, proved particularly effective in generating visual representations rooted in the site's *genius loci* and expressing both tangible and intangible heritage. For example, the Amphora system, inspired by ancient Roman containers, evokes historical memory by merging creativity with site-specific knowledge. Stakeholder engagement and visitor interviews helped spatially map user needs across the site. For instance, interviews conducted for the Complesso of Santa Croce revealed visitors' desire to spend more time on-site, particularly in areas designed for children. This insight was applied in the development of the Loop system. However, more structured participatory co-design methods could further improve alignment with audience expectations.

The Artifacts Project phase, focused on developing physical objects, demonstrates how concept-driven design can be effectively translated into functional, tangible solutions through the integration of appropriate technologies.

The Activation phase illustrates how spatial integration of artifacts can redefine the visitor experience by generating new paths and interaction nodes throughout the site. However, the project faced constraints due to its educational context. Specifically, it concentrated on design and scale modeling without direct field testing, and limited resources prevented full physical implementation. Consequently, evaluations relied on simulations and virtual representations, leaving open questions about real-world effectiveness unresolved.

Despite these constraints, the educational process provided students with a valuable opportunity to engage with real-world complexity. By collaborating directly with interdisciplinary teams and cultural institutions, they developed both design competencies,

such as spatial thinking, modular design, and sensory interaction, including collaboration, adaptability, and stakeholder communication. They learned that a user-centered approach and careful observation of real contexts are essential for guiding meaningful design decisions.

The structured three-phase methodology (Inspiration and Knowledge, Artifacts Project, Activation) provided a pedagogical scaffold, aiding students in managing the complexity of working with historical sites and, more broadly, the project's overall challenges. A key difficulty was balancing creative freedom with respect for historical contexts, a tension amplified by the students' limited cultural background in cultural heritage.

Moreover, the limitations themselves, such as the absence of prototyping and limited technological expertise, became learning moments. Students were prompted to reflect on the importance of interdisciplinary collaboration, the value of testing, and the challenges of designing for diverse audiences in sensitive contexts.

This research proposes a conceptual design approach that bridges tangible and intangible cultural heritage through participatory and multisensory experiences, rather than rigorously testing a formal theoretical model using quantitative methods. The three-phase framework provides a guiding structure for this exploratory design process.

Additionally, it would have been advantageous to provide assistance to the design process during the initial and second phases by acquiring specialized user experience expertise in programming and graphics for interactive web interfaces. The lack of such skills and the development of interactive technologies limited the innovative potential of the projects. A more structured integration with external experts could have expanded the effectiveness of the proposed solutions.

To enhance future initiatives, integrating specialized expertise in interactive technologies and user experience, especially in the early design phases, could increase innovation and usability. Likewise, rigorous on-site testing and quantitative evaluation will be essential to validate the impact of the proposed artifacts.

Despite these critical issues, the design experience represented a unique opportunity for the students to address real cultural heritage issues using a human-centric, multidimensional design approach. The implemented projects are effectively incorporated into the historical context, exhibiting complete respect for their significance. Ultimately, the project reinforces the value of a participatory and multidisciplinary approach, capable of turning the constraints of historical environments into opportunities to promote an innovative and sustainable vision of cultural heritage.

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The author declares that generative AI or AI-assisted technologies were not used in any way to prepare, write, or complete this manuscript. The author confirms that they are the sole authors of this article and takes full responsibility for the content therein, as outlined in COPE recommendations.

Informed Consent

This study was conducted with the informed consent of all participants.

Conflict of Interest

The author declares that there is no conflict of interest.

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