

THE ENHANCEMENT OF CULTURAL ECOSYSTEMS THROUGH AN INCLUSIVE DESIGN APPROACH: THE CASE STUDY OF THE “MUSEO DIFFUSO LETTOMANOPPELLO”

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ABSTRACT

Enhancing the usability, accessibility, comfort, and user experience of cultural heritage, particularly within small or dispersed museums, has become a key challenge for contemporary design research. In these contexts, the lack of technological infrastructures, effective wayfinding systems, and inclusive and ergonomic communication tools often limits visitor engagement, resulting in cultural and perceptual exclusion and diminishing local identity. Ergonomics and Design for All offer valuable frameworks to address these limitations by promoting a systemic approach that integrates human-centred, inclusive, and sustainable principles across different design domains. This paper investigates how these principles can be applied to cultural heritage through digital solutions, interaction design, service design, and communication systems that connect physical and digital experiences. The study presents the Museo Diffuso Lettomanoppello, an open-air museum in the Abruzzi Region, conceived as a living laboratory for experimentation of multisensory and inclusive design. By combining contextual analysis, participatory co-design, and the development of ergonomic and accessibility metrics, the project demonstrates how the integration of Design for All and Ergonomics can transform small cultural sites into dynamic, connected, and inclusive ecosystems. The findings highlight the potential of such combined approach to strengthen identity, participation, and sustainable development within marginal cultural contexts.

INTRODUCTION

In recent years, the integration of cognitive ergonomics with Design for All has played a pivotal role in innovating design processes applied to cultural heritage within systemic design frameworks (Martins & Gabriele, 2013). The progressive digitisation of museum experiences, combined with the need to ensure physical, cognitive, and digital accessibility for diverse audiences, requires careful consideration of usage models, communication interfaces¹, and the relationships between body, space, and information (Yap et al., 2024).

¹In this paper, the term interface is used in an expanded sense, referring not only to digital tools but also to physical and communicative artefacts—such as signage, spatial markers, and interactive installations—that mediate the user experience within the museum environment.

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In small Italian towns ², promoting cultural heritage—both tangible and intangible—is crucial for triggering territorial regeneration. In contexts marked by depopulation, loss of identity, and marginalisation, identifying sustainable and participatory revitalisation strategies becomes essential. Innovative forms of cultural engagement, such as open-air and distributed museums (Lerario, 2025), are emerging as dynamic networks connecting people, art, and territory rather than closed, centralised institutions. Within this framework, ergonomic design plays a systemic role by reinforcing the relationship between users and their environment through sensory comfort, clear information, and usable interfaces, while fostering inclusion and active participation in heritage processes (Kasemsarn, Harrison, & Nickpour, 2023). This aligns with the new ICOM definition (2022), which defines museums as “permanent, accessible, inclusive, and participatory institutions that work with and for communities.” Inclusion, when sided with sustainability thus become strategic levers for heritage enhancement in smaller towns. These concepts have been applied in the design and implementation of the Museo Diffuso Lettomanoppello, an experimental cultural laboratory developed in Lettomanoppello, a small town in the Abruzzi Region. The project addresses a widespread condition in small towns: despite a rich tangible and intangible heritage, they often lack digital infrastructures and participatory strategies for cultural development, as traditional top-down approaches overlook the social and experiential dimensions of accessibility. The Museo Diffuso Lettomanoppello was conceived as a living laboratory integrating research and co-design with local stakeholders and citizens – as per Design for All Approach (Rossi & Barcarolo, 2018). Characterised by its stone heritage—over forty pietrales (Figure 1) engravings in Majella stone—and contemporary sculptures integrated into the landscape, the town lacked digital and communication systems, limiting their visibility and accessibility. The Museo Diffuso Lettomanoppello was conceived as a living laboratory integrating research and co-design with local stakeholders and citizens – as per Design for All Approach (Rossi & Barcarolo, 2018). Characterised by its stone heritage—over forty pietrales (Figure 1) engravings in Majella stone—and contemporary sculptures integrated into the landscape, the town lacked digital and communication systems, limiting their visibility and accessibility. The project therefore adopted a systemic, interdisciplinary approach combining technological innovation, sustainability, inclusiveness, and ergonomics to create an integrated ecosystem of physical and digital artefacts, branding strategies, and accessible routes that foster participation and multisensory engagement.

²Italy has over 5,500 small municipalities (fewer than 5,000 inhabitants), covering about 70% of the national territory and housing nearly 10 million people. These inland and mountain areas face persistent challenges of depopulation, ageing, and limited access to services and culture (ISTAT, *Atlante dei Piccoli Comuni*, 2022).

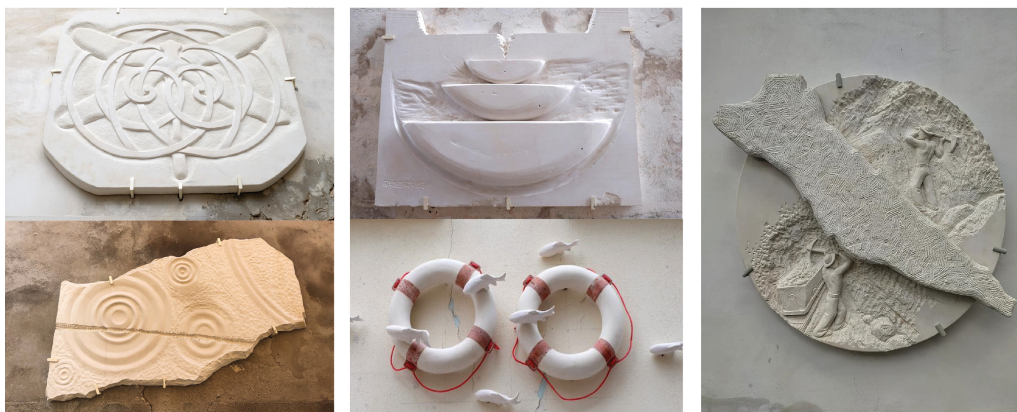


Figure 1. Examples of “pietrales” in Lettomanoppello.

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RESEARCH OBJECTIVES

The study aimed to develop and validate a preliminar model for a distributed inclusive museum, created through co-design and inclusive design principles, to promote sustainability, social inclusion, territorial cohesion, and technological innovation in cultural heritage. To do this, both principles of cognitive and Design for All have been applied to enhance the enjoyment of widespread cultural routes. Furthermore, a systemic approach was adopted across different design areas with the goal of developing solutions that were usable by the widest possible population of users, both visitors and local stakeholders (i.e., citizens). The specific objectives were:

- To design and integrate digital solutions, services, communication systems, and wayfinding tools within a widespread museum model, enhancing overall user experience and engagement.
- To evaluate the value of the Museo Diffuso Lettomanoppello as a scalable model for similar contexts, on the basis of socio-economic, human-centred, collaborative, and cultural metrics.
- To assess how ergonomic principles improve inclusiveness and accessibility, and to identify indicators suitable for evaluating the effectiveness of communication and digital tools in terms of usability and user engagement.

METHODOLOGY

The research adopted an integrated 3-stage approach, combining both qualitative and quantitative methods used in Design studies (Shuttleworth, 2008) with on-site live sessions that involved local stakeholders to translate insights into design outlines. This ensured that the project addressed the needs of all social groups, including people with disabilities, and different age and socio-economic groups. The aim was to reduce the technological gap affecting the accessibility and “usability”³ of cultural heritage in Lettomanoppello case study, through systemic strategies grounded in ergonomic design principles. To achieve these objectives, the project applied the Method for System Design for Sustainability (MSDS) (Vezzoli, 2007), which is a flexible sociotechnical design-oriented approach that integrates sustainability principles at a systemic level while promoting responsible design practices (Figure 2).

³In this study, “usability” extends beyond the ISO 9241-11:2018 definition to include the experiential quality and overall accessibility of the cultural heritage environment, interpreted through ergonomic and systemic design principles.

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METHOD FOR SYSTEM DESIGN FOR SUSTAINABILITY (MSDS)

applied to the Museo Diffuso Lettomanoppello

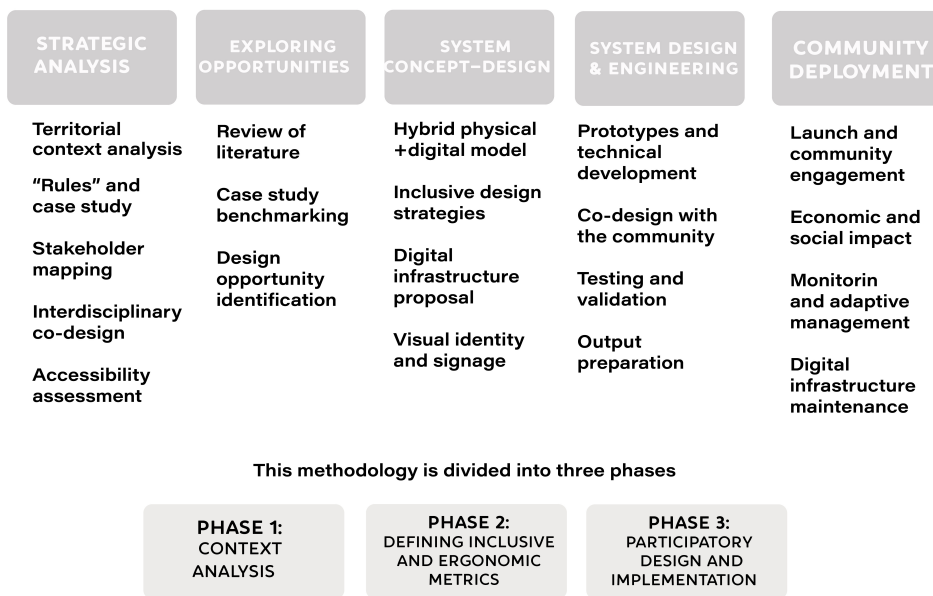


Figure 2. Adapted Method for System Design for Sustainability (MSDS) applied to the Museo Diffuso Lettomanoppello

This framework supports a holistic approach to sustainability, ensuring that digital design solutions are effective, ergonomic, and durable while enabling a comprehensive exploration of the widespread museum phenomenon.

Context analysis

The local context analysis followed three main steps: (1) literature review, (2) field data and interviews, and (3) mapping of artworks. The review addressed three main thematic areas: (a) the diffuse museum and its theoretical evolution, (b) urban art for territorial regeneration, and (c) ergonomic and inclusive design in cultural contexts, with an emphasis on improved user experience. A contextual study of Lettomanoppello examined the *pietrales* (and their socio-cultural relevance, focusing on accessibility and usability through site surveys and documentation. Fieldwork and interviews with artists and residents revealed local perceptions and expectations. As noted by Groat and Wang (2013), such analyses are crucial for understanding community needs and guiding targeted accessibility strategies. Stakeholders—including local authorities, cultural associations, and artists—were identified. Particular attention was paid to the potential needs of users with diverse abilities (e.g., blind and partially sighted persons, deaf and hard of hearing persons) during the analysis. The results confirmed the lack of digital, communicative, and wayfinding systems, with fragmented information and limited access routes hindering user interaction. Overall, Phase 1 revealed major gaps in accessibility and digital infrastructure, reinforcing the need for an inclusive, ergonomic approach to enhance user engagement and cultural participation

Defining inclusive and ergonomic metrics

This phase established clear design objectives and evaluation criteria aligned with ergonomic and Design for All principles to improve accessibility, usability, and the experiential quality of urban artworks. A benchmark of national and international case studies enabled the definition of metrics for physical, digital, and cognitive accessibility, economic sustainability, tourism impact, and

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community engagement. These provided strategies tailored to the context of Lettomanoppello, with particular attention to cognitive ergonomics, interaction, and service design. The resulting metrics were translated into ergonomic indicators such as (a) accessibility, (b) interface readability, (c) perceptual comfort, and (d) communicative clarity, which were used later to guide and assess the effectiveness of design solutions developed. Ergonomics was treated not as a final verification step but as an active, iterative element within the design process.

Participatory design and implementation

The design phase embodied the inclusive principles of Design for All, translating them into digital, communicative, and spatial solutions centred on the user experience. An integrated system of products and services was developed to enhance public art and the local stone heritage through physical and digital artefacts (Giaccardi, 2015), creating an accessible, participatory, and multisensory experience. Through participatory co-design, the community, artists, and stakeholders contributed in three iterative steps. The initial phase—critical mapping—focused on accessibility. To facilitate improved access to “pietrales”, a set of accessibility design actions were undertaken to remove architectural barriers and eliminate the tone-on-tone effect (re: white stone-made artwork on/sided on white walls), that hindered their visibility. A new pietrales route was developed, offering short, medium, and long itineraries to provide a diversified experience appropriate for diverse target groups (Figure 3).

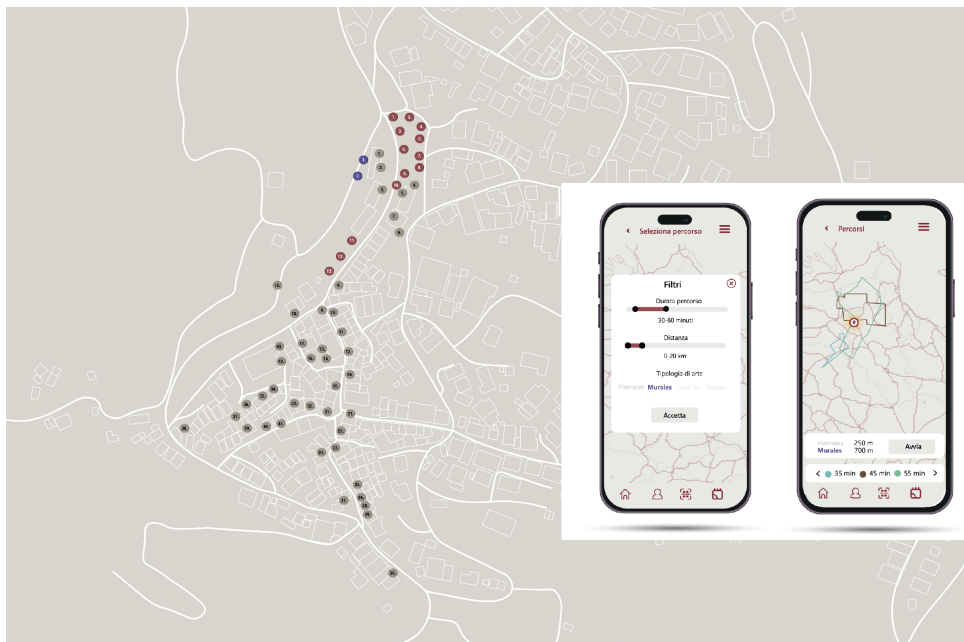


Figure 3. Map of the 'Pietrales Route'

Simultaneously, the digitisation of the stone heritage has begun, consisting of photographing the works and creating an archive. The integration of augmented reality in a mobile application facilitates access to multimedia content, in-depth information, and audio guides during physical visits (Figure 4).

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STEPS FOR PIETRALES AR ANIMATION
DEVICE: APP MOBILE

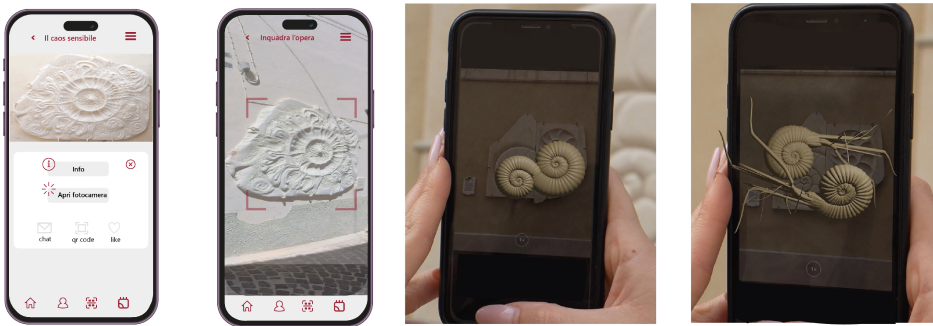


Figure 4. Digitalisation process and augmented reality integration

The inclusive visit experience phase developed hybrid phygital works, reinterpreting pietrales through augmented reality and digital storytelling co-created by stonemasons and digital artists. Digital interaction was designed to be intuitive and accessible, following ISO 9241-210 (2019) human-centred design principles and a Design for All approach, ensuring usability for users with cognitive, visual, and hearing impairments. The museum as a platform phase envisioned the Museo Diffuso Lettomanoppello as a regional hub connecting art, territory, and community. Long-term sustainability strategies—microfunding, residencies, and creative calls—promote belonging and a circular cultural economy. The museum operates as an evolving ecosystem linking people, spaces, and information, accessible both on-site and remotely. The project demonstrates how integrating ergonomics and Design for All can transform a diffuse museum into an inclusive, technology-driven system fostering participation and sustainable territorial development.

DEVELOPMENT OF THE PROPOSED MODEL

The proposed model for the Museo Diffuso Lettomanoppello defines an integrated cultural ecosystem (Figure 5).

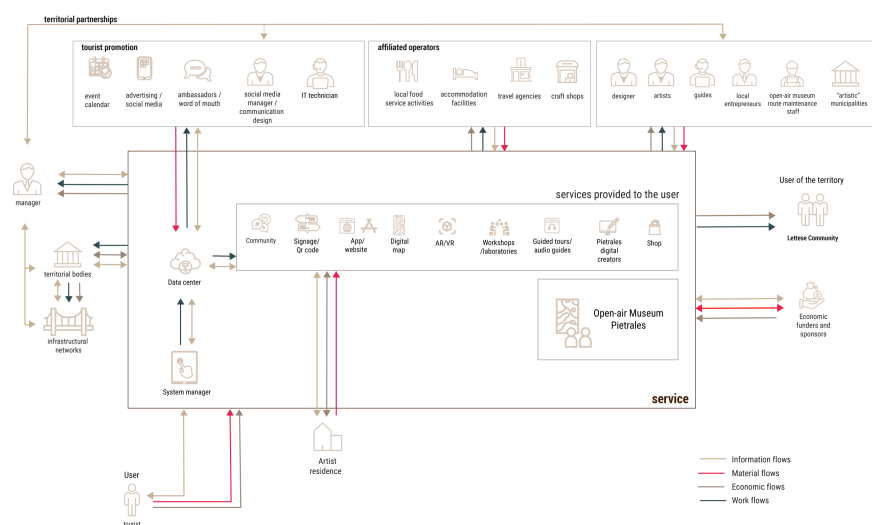


Figure 5. System Map

The user experience combines digital solutions, interactive devices, communication systems, and physical and cognitive orientation tools. The aim was to outline a model replicable in other museums and urban contexts. This system embodies human-centred design principles, where technology

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enhances visitor access, understanding, and comfort. The model adopts a modular use of digital infrastructures—a web platform, a mobile app, and on-site interactive devices—allowing users to engage with content before, during, and after their visit. Consistent with Allen and Lupo (2012), contemporary museums as relational communication environments in which technological mediation fosters participation, engagement, and knowledge construction. The web platform operates as an archive and a virtual space for participation, collecting digital artworks, technical data sheets, and thematic maps. The website also tasks as a digital hub for users and artists, featuring a membership and customer loyalty section. This segment encompasses initiatives related to donations, the commissioning or adoption of artistic works, and pertinent contact information. In addition, the website contains a login section and an online store where users can purchase branded merchandise. The mobile application integrates augmented reality (AR) and geolocation functions with proximity notification activation, enabling digital narrative layers to be superimposed on physical works along the museum's routes and improving visitor autonomy and safety. In addition to the provision of 'augmented' navigation, the ARTCreator tool facilitated the co-creation of content by users, allowing them to design their own work and participate in contests, thereby increasing their engagement during their visit. The digital solutions that have been designed to reduce the digital divide have been developed to support both on-site visits and remote, on-demand experiences. The promotion of accessibility of heritage and the inclusive and sustainable enjoyment of culture is, thus, a key objective of these solutions. The visitor experience employs interaction design principles, offering tailored itineraries based on interests, time, and accessibility. The museum's communication system and visual identity are underpinned by principles of accessibility and information design (Frascara, 2015), structured within a multi-level information hierarchy that ensures clear, multilingual, and interactive content designed according to visual ergonomics criteria. The wayfinding system (Figure 6) is founded on the principles of cognitive and environmental ergonomics, and has been designed to facilitate intuitive orientation, even in the absence of digital support.

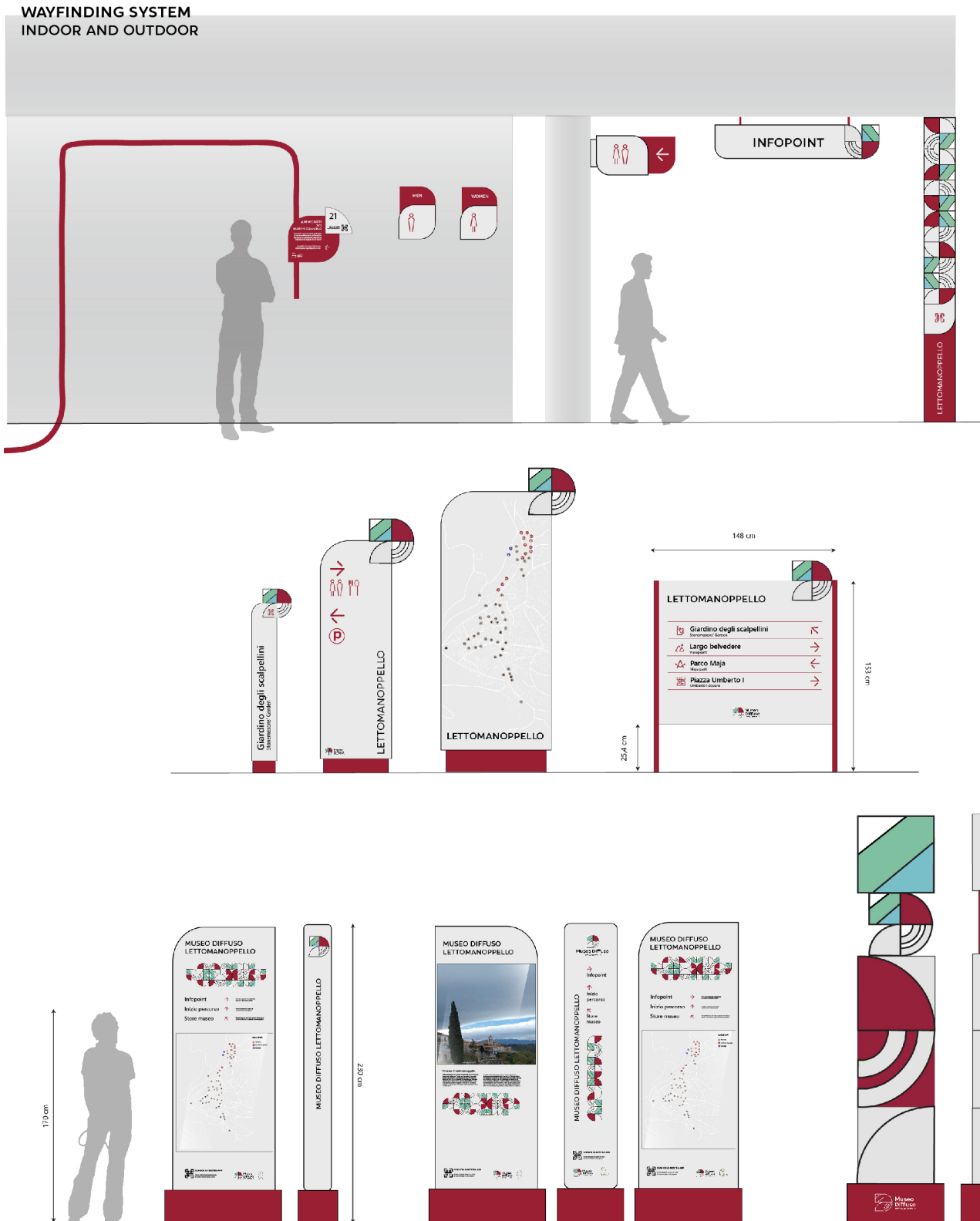


Figure 6. Wayfinding system and signage design

The system has been meticulously designed to assist visitors in navigating through the museum and comprehending its interconnections with the surrounding area. The signage is intended to ensure optimal visibility at different distances and comprises the following elements:

- museum information panels with interactive displays for personalised content;

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- vertical and horizontal directional signage for both indoor and outdoor environments;
- multisensory maps featuring tactile reliefs;
- decorative totems serving as recognisable museum symbols.

Furthermore, ad-hoc floor signage (Figure 7) has been proposed to facilitate navigation throughout the museum without the necessity of additional digital or physical tools, such as apps or paper maps.

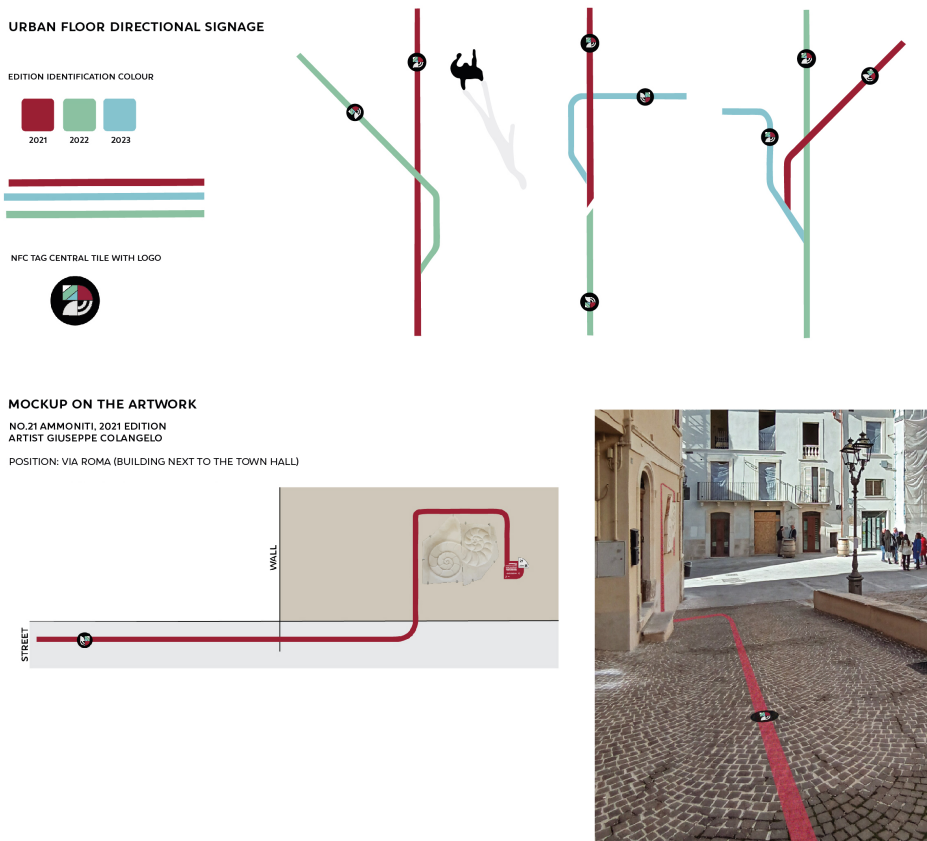


Figure 7. Floor and wall wayfinding elements

This removable, repositionable, and recyclable wayfinding also frames artworks as wall signage, ensuring immediate visibility. Explanatory plaques are to be found alongside all works on the museum route, and these are equipped with QR codes and NFC tags. The latter allow immediate access to text descriptions, accessible information sheets, multilingual audio guides, and videos in Italian Sign Language (LIS). The integration of these user-friendly digital technologies, open-source platforms and physical communication artefacts facilitates the replication of the system in other territorial contexts.

DISCUSSION

The project developed in Lettomanoppello generated observable results demonstrating the validity of a systemic model for art and cultural heritage promotion, along with the value of ergonomic and inclusive approaches in the enhancement of 'small-towns' heritage. It showed that, when guided by human-centred design principles, technology becomes a means for improved access and participation that broadens the usability and experiential scope of heritage. The initial phase went beyond cataloguing and digital archiving by applying organisational ergonomics to involve residents in data collection and decision-making, fostering shared responsibility and local ownership. The designed thematic routes identified informed an integrated wayfinding system

that combined physical and digital tools to meet cognitive ergonomics and the phygital heritage approach (Lo Turco & Giovannini, 2020). This ultimately resulted in improving orientation, accessibility, and visitor experience. Phase 3 confirmed the effectiveness of this approach by showing how the integration of ergonomics and Design for All can foster tangible improvements in usability, comfort, and community engagement. Cognitive ergonomics optimised information hierarchies and interaction consistency, reducing cognitive load and improving orientation. Human Centred Design guided route accessibility and signage placement, enhancing visibility and comfort, while Design for All sustained participation and co-creation of context-based identity. The creation of digital pietrales and their virtual placement acted as participatory interfaces, transforming heritage interpretation into a shared, inclusive experience. Overall, the Lettomanoppello model demonstrates how an ergonomic and inclusive framework can enhance accessibility and user experience, offering a replicable model for small-town cultural systems.

CONCLUSIONS

The inclusive enhancement of cultural heritage in small towns has become a key strategy for reducing regional inequalities, countering inland abandonment, and promoting sustainable development. In this context, a systemic and inclusive approach has been proven to be an effective strategy for addressing the complexities of these territories. The design process employed for the creation of the Museo Diffuso Lettomanoppello demonstrates an innovative model for applying ergonomics and inclusive design principles across multiple fields—exhibition, interaction, cultural heritage, service, and communication design—resulting in an open-air museum where digitalisation and communication promote sustainable and inclusive visit experiences. Integrated digital solutions- e.g., website, apps, and interactive devices – have enhanced accessibility and redefined the parameters of cultural enjoyment. The combination of communication strategies with physical and digital artefacts proved effective in fostering inclusivity. The model also showed that integrating communication systems and wayfinding supports inclusion while activating participation, cultural micro-economy, and territorial cohesion. The vision set for open-air museum is no longer tied to a “place of passive contemplation”; it is now more aligned to a “living (eco-)system of relationships where knowledge is built through interaction and sharing” (interpreted from: Cipolla & Manzini, 2009). Combining user experience design, interaction design and service design paves the way for new inclusive museum paradigms, where technology becomes a tool for expression, relationships and a sense of belonging. As Jelinčić (2017) argues, cultural innovation extends beyond technological advancement. It involves the creation of participatory and sustainable ecosystems that strengthen local identity and empower communities. Likewise, Borowiecki et al. (2016) highlight how digital transformation reshapes cultural heritage practices, redefining accessibility and engagement within changing social contexts. To conclude, the Museo Diffuso Lettomanoppello's modularity, adaptability, and capacity to engage the community serve as a strategic exemplar for analogous initiatives and demonstrates how ergonomics and design can together build a more human-centred future for cultural heritage.

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SHORT BIO

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