International Association of Societies of Design Research Congress 2023
LIFE-CHANGING DESIGN
Politecnico di Milano
9-13 October 2023

Digital for heritage and museums: design-driven changes and challenges

Lupo, Eleonora*[a]; Carmosino, Giuseppe[a]; Gobbo, Beatrice[b]; Motta, Martina[a]; Mauri, Michele[a]; Parente, Marina[a]; Spadoni, Elena[a]; Spallazzo, Davide[a]; Rubino, Federica[a].

[a] Politecnico di Milano, Department of Design, Milano, Italy-
[b] University of Warwick, Coventry, UK - Centre for Interdisciplinary Methodologies
* eleonora.lupo@polimi.it

doi.org/10.21606/iasdr.2023.397

In the recent decade, cultural institutions have increasingly embraced digital technologies as key resources for accomplishing their mission and innovating their cultural activities. In the present work, we attempt to disentangle through a design-driven and multidisciplinary approach the challenges brought by digital transformation in the cultural heritage sector. A diversified research team has thus been involved to include scholars with different backgrounds around the common phenomenon of investigation of Digital (Cultural) Heritage, under the Design Think Thank project. The Introduction is followed by a Methodological section, which outlines the approach to select and review case studies from the exploratory literature for producing a state-of-the-art report and delineates the methodology to map the main user behaviours and needs in the digital experience of CH throughout the value chain. The research team identified three relevant and major themes for the investigation: Digital Transformation, Inclusive Engagement and New Experience Rituals, which are addressed in the Literature Review Section. The state of the art is being addressed through the lenses of design research and practices; simultaneously, design knowledge emerges to have an agency in the transformation. The following section tries to triangulate the results from the literature review, and the mapping of users and stakeholders throughout the cultural institutions value chain, to track and highlight their role and interest in changing heritage panorama. The contribution of the present work wishes to consolidate the results gathered in the first phases of the TT, providing the design community of academics and practitioners with a theoretical contribution about digital changes and challenges of heritage and museums based on a design perspective.

Keywords: cultural heritage; museums; digital transformation; design knowledge

1 Introduction

Recent profound social, technological, and economic changes set cultural institutions new challenges for the upcoming years. The COVID19 pandemic has accelerated the digital transformation processes, which were already occurring in the cultural ecosystem (Ministero della Cultura, 2023). As key

challenges to their survival and future success, museums should be prepared to access national and international funding, set digital priorities based on their mission, manage the impacts of climate change on heritage, and pursue inclusivity through overcoming cultural barriers.

Early signs of change are emerging in the cultural sector: digital technologies are increasingly broadening the cultural audience and the active participation of the public; as regards the role of museums, they are evolving into essential infrastructures for the community, enhancing collections through new forms of storytelling and in-depth itineraries, and providing greater experience, customization and information exchange for visitors (AA.VV., 2021; UNESCO, 2022).

The questions emerging from the current scenario are multiple, diversified, and cross-sectional through cultural institutions' value chain, which increasingly changes through digital endeavours. The underlying question of the present work, which justifies its focus, is how can design knowledge address the multi-layered transformations that are occurring in the Cultural Heritage (CH) field:

- Which design tools and practices can be employed for museums' audience engagement in the digital environment (Camarero et al., 2015)? How do designers contribute through participatory tools to the involvement of audiences both online and offline in the museum (Gretchen et al., 2019)? Which frameworks can be developed to foster the multimodal fruition of heritage on-site, enriching CH with new layers of information (Lupo et al., 2014)?
- How can CH professionals be empowered to become more active players in the ideation and realization of digitally enhanced visitor experiences through design-led initiatives?
- How to design, in an interdisciplinary approach, human-centred technology for a real and meaningful user-centred accessible CH (Arenghi et al., 2016)? Which methodologies can be developed to promote consistent documentation of digital intangible CH?
- How are cultural institutions adopting disruptive and emerging technologies (Valeonti et al., 2021), and how are digital technologies increasingly affecting cultural institutions organizational and management practices (Taormina & Baraldi, 2021)? Which new participatory models and frameworks can be designed to foster museums' organizational change (Peacock, 2008)?

To tackle these questions, we as a group of researchers stand for promoting a design-driven and multidisciplinary approach, both on a practitioners' level, and for future research agendas. The objective is not to answer directly to all questions, but to provide a context of design based knowledge to review, discuss and manage those issues innovatively. Design research and practice has been pushed from the complex transformations of contemporary society to evolve to be increasingly multidisciplinary as a discipline, shaping and being shaped by social environments, products, services, systems, experiencing new hybridizations of the disciplinary boundaries (Manzini, 2004). Therefore, a research team has been involved to include scholars with different backgrounds around the common phenomenon of investigation of Digital (Cultural) Heritage.

This paper's research has been conducted in the context of the Polimi Design Think Tank (TT), which operates within the Department of Design at the Politecnico di Milano. The TT's primary objective is to advance the use of design as a tool to inform decisions related to innovation and internationalization strategies within the national productive economic sector, and to promote design as a tool to transform advanced research into convergence of innovation in multiple economic sectors.

This paper centres on one of the two pilot projects[1] of the TT, which entails scrutinizing and assessing the pressing topic of innovation concerning Digital Heritage (DH). Working groups are organized within each TT to operate in synergy on different aspects of the same theme, thereby promoting osmotic contamination among them. Furthermore, a mixed composition in terms of interests and experience favoured the intersection of contributions from different design sub-fields.

Our instance consists into analysing and looking at the digital transformation occurring in the CH field through the lenses of design research, and to advocate the potential of this discipline in contributing to the process of transformation occurring in the CH field, at different levels of cultural production, guiding it into virtuous and sustainable changes. We advocate for design knowledge as a lens of observation of the changing heritage phenomena, but most of a driver for transformation and for fostering participation in innovation processes (Bertola & Teixeira, 2003).

2 Methodology

This section will elucidate the methodology employed in the research, organised in two different strands[2]. In section 2.1, the paper outlines the adopted approach to select and review case studies from the literature for producing a state-of-the-art report. In section 2.2, the paper delineates the methodology to define the needs and behaviours of users.

2.1 Literature review

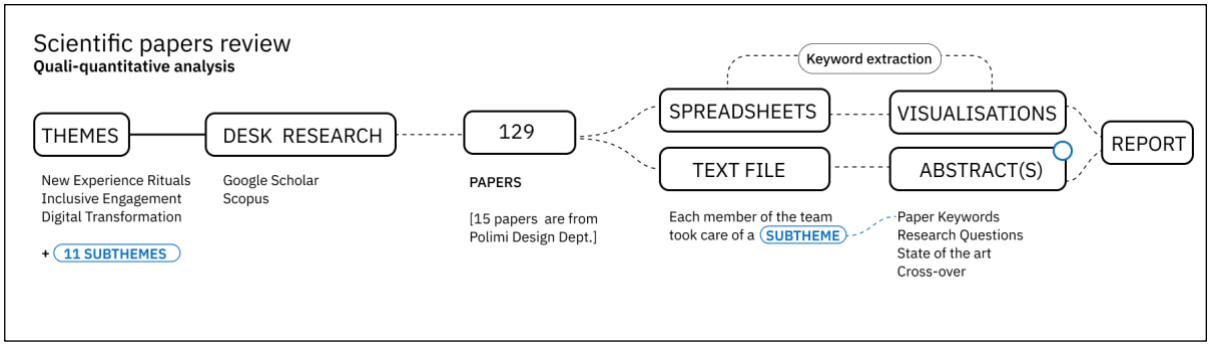

Figure 1: diagram summarising the semi systematic approach underlying the production of the state-of-the-art report for Digital CH. These steps have been carried on by the Bibliography analysis working groups

The research team identified three relevant and major themes for the investigation: Digital Transformation, Inclusive Engagement and New Experience Rituals (Figure 1). As will be further explained in the following paragraph and in the conclusions, a design driven approach guided the selection of the themes, focusing on topics that are informed (or can be) by design and above all present in the Design department areas and groups of research, and clustering them in these three major strands.

[1] Alongside the TT on Digital cultural Heritage, another group of XXXX design researchers focused on the Digital Health realm.
[2] A parallel work was conducted from another research group about the patent review (which is not reported in this paper).

In fact, due to the TT's specific goals, aimed at valorising existing research strands within the Department of Design for strengthening its potential of collaboration with the CH stakeholders, it was deemed simplistic to conduct quantitative bibliographic research, focusing on an extensive and systematic state-of-the-art analysis. Indeed, the more advantageous approach was pinpointing the Design Department's areas of interest and expertise within the context of DH, following a semi-systematic approach (Snyder, 2019). After a qualitative and iterative process to identify emerging topics in DH outside and inside the Department of Design, the three primary themes have been rearranged and extended. Thus, eleven sub-areas have been identified: organisational change, capacity building and digital literacy, digital asset preservation, copyright and creative commons, disruptive technologies, cultural inclusivity, engagement and cultural outreach, immersive and extended reality, connectedness, sensitive Heritage and entertainment.

DIGITAL HERITAGE		
DIGITAL TRANSFORMATION	**INCLUSIVE ENGAGEMENT**	**NEW EXPERIENCE RITUALS**
• Organisational Change • Capacity Building , Digital Literacy • Digital Asset(s) Preservation • Copyright-CC • Disruptive Technology	• Cultural Inclusivity • Design Meth. for Engagement and Cultural Outreach	• Immersive-extended • Connectedness • Sensitive Heritage • Entertainment

Figure 2: diagram summarising the final articulation of the DH themes

Starting from the themes presented in Figure 2, which were sorted into the working group, allocating a couple of topics for each component, a total of 114 papers manually selected have been collected. Scientific articles have been mainly gathered through Scopus and Google Scholar, using as prompts the keywords and expressions listed in Figure 2. The selection criteria for these papers focused on relevance and recency. The group sought the most ten pertinent contributions that were no more than ten years old and considered as relevant some papers dating back to 20 years. In addition, 15 recent papers from the Department of Design, Politecnico di Milano, were allocated to each subtheme and included in the collection. All the records have been translated in a shared spreadsheet, to facilitate further review and classification.

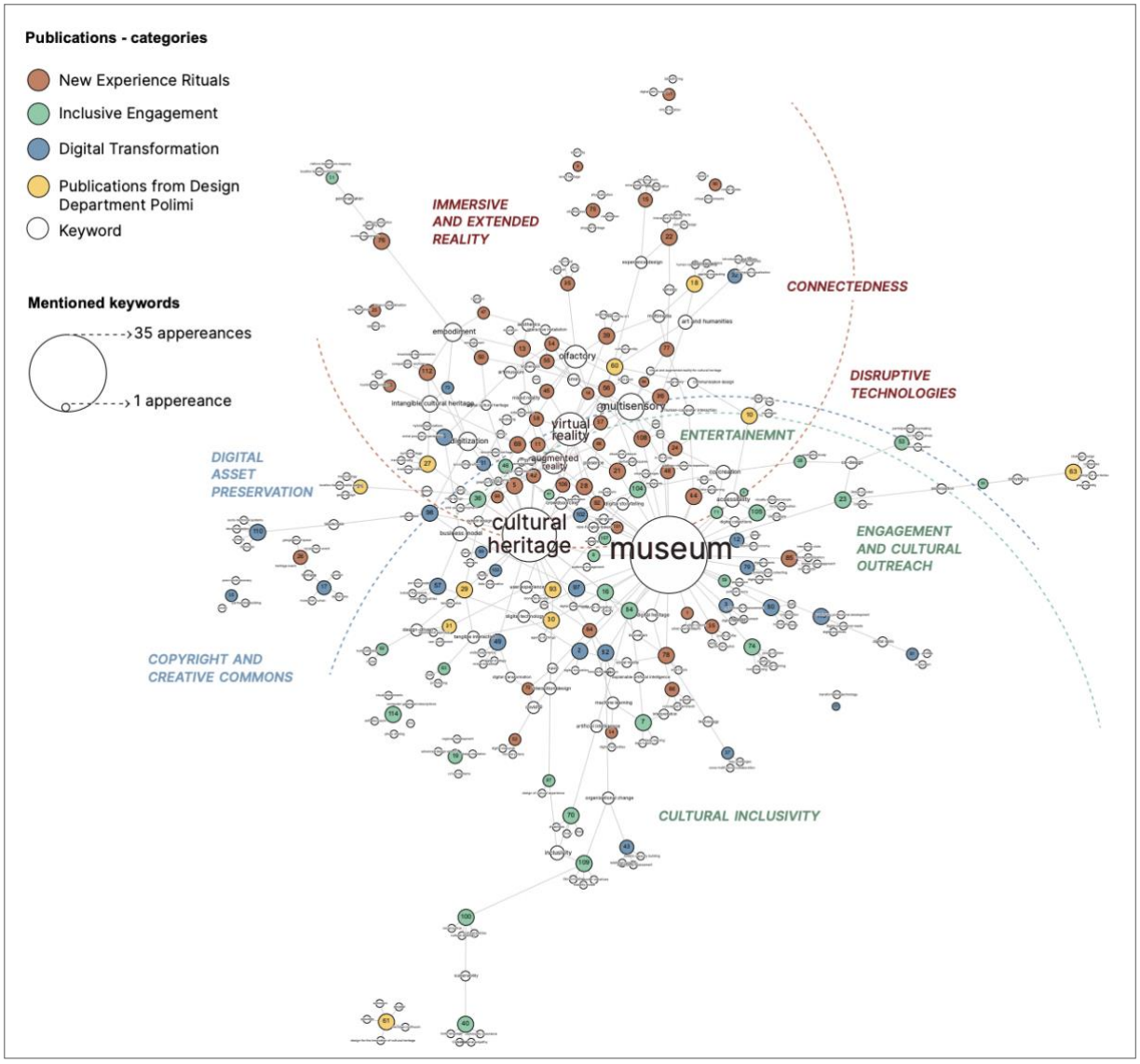

Figure 3: network graph showing the co-occurrences of keywords in the corpus. In general, we can say that museum, CH and virtual reality are the most recurring keywords in the corpus and that there are scattered areas of the network which are overseen by the Design Department of Politecnico di Milano.

Within this stage, each paper was enhanced by the addition of author-provided keywords, citations, and publication year. The classification process outlined herein provided the groundwork for curating the obtained results as textual content and visual representations. The textual content concentrates on depicting each subtheme's state-of-the-art, raising new queries, and identifying cross-themes relationships. The visualization (Figure 3) aimed to present the findings and highlight noteworthy topics, potential areas for intervention, and the Department's position within the global scientific community.

2.2 User needs and behaviours

The second strand of the TT, named “user needs and behaviours”, was aimed at elaborating, starting from the research questions and topics derived from the literature review, the main user behaviours and needs in the digital experience of CH.

The research team addressed with an ecosystem approach the definition of heritage users and needs, looking at the whole stakeholder's constellation in the different phases of the digital heritage value chain, to individuate the complex needs of the digital heritage ecosystem. In the CH field user is often associated with end-users, that is museum visitors or, in a larger view, the audience and public; for the purpose of the research, it was crucial to encompass all the agencies that act, create value or whose interest might be affected in all the emerging topics and themes of digital heritage disclosed by the literature review. Accordingly, behaviours and needs circumstantiate the complex situations in which the heritage stakeholders perform their competences, actions, and decisions, often in a systemic way.

The research team decided therefore to:

1. map the digital heritage stakeholders according to their contribution and multi-role positioning in the digital heritage value chain stages;
2. prioritize and give evidence to some macro-themes and open questions, hinged upon the different stages of the value chain and indirectly addressing all the potential stakeholders and participants involved in each stage.

The proposed digital heritage value chain is based on an adaptation and synthesis of both Porter's Museum Value Chain (Porter, 2006), and the study promoted by the EC "Mapping the creative value chain" of 2017.

Starting from the end users, the stakeholder system populates the entire chain of value creation going back from the experience design up to the stages of management and development strategy, to unfold the potential contribution of the stakeholders within all the museums functions and activities, and "pursuing physical proximity among players belonging to different cultural and creative sectors" (Sacco et al., 2018): it includes museum professionals, CCIs, tech providers, the wider community. This approach clearly aligns with the vision of the H2020 Report on Museums, which proposes a shift in the challenges for the technological development of museums "from short term trends at the end-use level (i.e., Mobile Content and Delivery or Participatory Experiences) to mid/long-term trends at the management level (i.e., Cross-Institution Collaboration and New Roles for Museum Professionals)" (Freeman et al., 2016).

Operatively, the team worked in a collaborative space on Miro, where on a board the different value chain functions were positioned in a linear sequence and stakeholders were added and clustered around the stages, differentiating among actors internal or external to the cultural institution. As shown in Figure 4, 16 value chain stages /functions and in total 29 typologies of actors (internal and external) have been initially individuated. Where possible, specific actors or projects have been added also as case studies.

STAKEHOLDERS INTERNAL TO CULTURAL INSTITUTIONS/ MUSEUMS	VALUE CHAIN STAGES/ FUNCTIONS	STAKEHOLDERS EXTERNAL TO CULTURAL INSTITUTIONS/ MUSEUMS
• Board of directors/Directors	**Funding**	• Organisation
• Board of directors/Directors	**Regulation**	• Policy makers
• ICT team • Archivist	**Preserve: digitize**	• Tech development • Tech provider/support
• ICT team • Archivist	**Preserve: maintain (restoration, analysis)**	• Companies specialized in exhibition design and systems for museums • Tech provider/support
• ICT team • Curators exhibitions/installations • Communication Team (panels/graphic)	**Preserve during the exhibition (advanced exhibition systems, public management systems, exhibition design...)**	• Companies specialized in exhibition design and systems for museums • Consultancy, designers, architects, ICT developer
• Curators • Board of directors/Directors	**Conserve/manage**	• CCIs • Local communities
• Curators • Registrar • Board of directors/Directors	**Sell/lend**	• Collectors • CCIs
• Archivist	**Store (archive, catalogue)**	• CCIs • Local communities • Tech provider/support
• Communication Team (panels/graphic) • Curators • ICT team	**Enhance/promote**	• CCIs • Local communities • Tech provider/support • Organisation
• Education managers • Educative services	**Enhance: transmit/ educate**	• CCIs • Local communities • Tech provider/support • Academy
• Curators	**Content creation and co-creation**	• CCIs • Local communities • Community • Final users • Fablabs • Tech provider/support • Friends of museum
• Museum shop management • Educative services	**Creation, development and management of services**	• Tech development • Tech provider/support • Museum shop management
• Communication Team (panels/graphic) • Marketing Team (promotion and fund raising)	**Media and communication**	• Companies specialized in exhibition design and systems for museums
• Marketing Team (promotion and fund raising)	**Public management**	• Tech provider/support • CCIs • Community • Friends of museum
• Reception, logistics and security • manager	**Monitoring inputs**	• CCIs • Tech provider/support • Friends of museum
• Curators • Communication Team (panels/graphic) • ICT team • Educative services	**Enjoyment**	• CCIs • Tech provider/support • Visitors

Figure 4. Digital Heritage Ecosystem: Value chain stages and stakeholders

The 16 value chain stages above presented, have been informed by the sub-themes generated by the literature review (Section 2.1), elaborating them in macro-functions that critically frame and cluster the needs in each value chain stage and engage the different stakeholders.

These macro-functions include the more important functions of the value chain (and relative stakeholders' constellations):

1. Infrastructure & management. The main support functions of the cultural institution such as governance, fundraising, HR management, marketing. These functions in example are informed, among the others, by the following sub-themes of the literature review: organisational change, capacity building and digital literacy, disruptive technologies.
2. Preservation. The primary functions of the cultural institution such as acquisition, digitization, cataloguing, conservation and restoration. These functions are informed by the literature review sub-themes: digital asset preservation, copyright and creative commons, disruptive technologies. These functions are informed by the literature review sub-themes: digital asset preservation, copyright and creative commons, disruptive technologies.
3. Audience development. Broadly, the actions that have an impact on the audience, from cultural and educational programming to the planning of exhibitions and events, memberships. These functions are informed by the literature review sub-themes: cultural inclusivity, engagement and cultural outreach, immersive and extended reality, connectedness, sensitive Heritage and entertainment, disruptive technologies.
4. Services. Includes all services from traditional to more innovative ones[3]. These functions are informed by the literature review sub-themes: cultural inclusivity, engagement and cultural outreach, disruptive technologies.

In this proposition, the macro-functions cluster the user needs and led to identifying some potential drivers of change (changing heritage drivers) to engage the various stakeholders with some open critical questions.

The process is synthetised in Figure 5.

[3] "Cultural services are services aimed at satisfying cultural interests or needs. They do not represent cultural material goods in themselves but facilitate their production and distribution. For example, cultural services include licensing activities and other copyright-related services, audio-visual distribution activities, promotion of performing arts and cultural events, as well as cultural information services and the preservation of books, recordings and artefacts in libraries, documentation centres, museums" UNESCO, 2009.

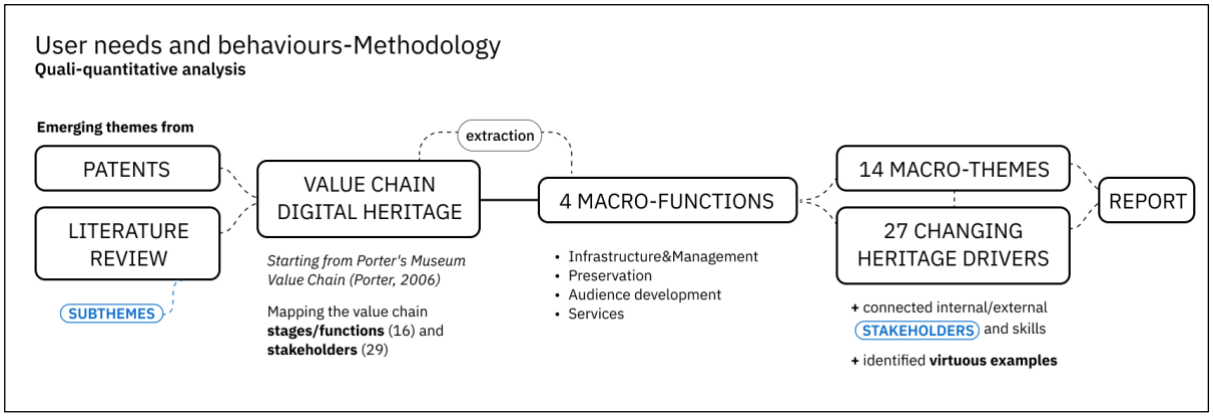

Figure 5: diagram summarising the approach adopted in the analysis of user needs and behaviours for Digital Cultural Heritage TT.

At the end, 14 macro-themes and 27 changing heritage drivers have been individuated (the full list will be presented in the next paragraph discussion). From the list is evident the richness and complexity of interest (complementarity and/or contradiction), perspective and skills possessed by the various stakeholders in the different stages and macro-functions. It is worth noticing that:

1. some macro-functions appear to present more design-related issues than others: audience engagement (which was expectable, since this represents the expertise mainly associated with the design approach in introducing digital technology applications in the museum visitor experience) and infrastructure & management (which was less predictable but reflects the emerging role of the design approach in enabling digital transformations and organizational changes in cultural institutions); apparently for the two macro-functions of preservation (with was unsurprising) and services (which is a bit unexpected) there is less evidence of the need for a design approach;
2. some changing heritage drivers (especially the one concerning the introduction of disruptive technologies, i.e., NFT) are transversal to the whole value chain, and applicable to more macro-stages.

All these considerations have been read as an opportunity for design intervention and will be discussed in the next paragraph.

3 Discussion

3.1 Literature Rreview

Following, we discuss the three streams and relative themes that have been individuated by the literature review. We start with the stream of “digital transformation” as it encompasses the strategic levels of museums and cultural institution, thus impacting on the other two streams of “inclusive engagement” and “new experiences design”.

3.1.1 Digital transformation and organizational change

Digital transformation has been challenging museums in terms of organizational implications (Taormina & Baraldi, 2022). The impacts of digitization on the museums’ value proposition and, consequently on their business model, are being increasingly studied. Even before the pandemic, Parry (2013) recalled the urgency for museums to develop an integrated analytical approach

concerning the operational, organizational, and strategic dimension. According to Kamaritou et al. (2021), digital museums should be designed strategically to achieve results in economic and social growth simultaneously. Increasing studies are concerned with understanding how digitization leads to hybrid forms of business models, to fulfil both commercial objectives and museums' social mission (Li, 2020; Alshawaaf & Lee, 2021). Indeed, technological innovation has the potential to affect several functions of the museum activity: conservation and management of collections, display of objects, customer service, media, and communication (Bertacchini & Morando, 2013). Scholars have started developing frameworks to quantify the impact of digitalization at the organizational level and their digital readiness (Agostino & Costantini, 2021) or to redesign the cultural organisation's working practices and processes (Mason & Vavoula, 2021). In this rapid changing context, a major challenge for museums is to integrate the traditional know-how with innovative digital skills for emerging professionals. A further challenge concerns the fact that while digital tools evolve rapidly, digital-driven changes in museum organization are less disruptive (Peacock 2008). Future research is particularly needed in this domain to understand how successful digital strategies needs to be integrated within the museum's overall vision, and to understand of how the new technologies can support decision-making processes (Esposito et al., 2021), especially through assessment frameworks (Agostino & Costantini, 2021).

3.1.2 Digital transformation: capacity building and digital literacy

The issue of capacity building and digital literacies shows a continuous process of change within cultural institutions. Infact, according with their mission, museums must update their skills, knowledge and systems to operate efficiently and adapt to changes, to remain relevant to stakeholders and serve communities by providing learning opportunities, and to preserve the objects and artifacts entrusted to them by the public. In this scenario, increasing the digital capacity of museums is one of the main aspects of concern, but not the sole. The Institute of Museum and Library Services enlightens as the main current change the gaining of a holistic understanding of capacity building, especially concerning with redistributing power, investing on unmet capacities and creating new relationship and partnership (Hausmann & Hackney, 2021). Digital skills and social media training are a transversal priority in this context (Fleming, 2021). Specifically on digital literacy, the report "Mapping the museum digital skills ecosystem" demonstrates that there is already a deeper understanding by museums of the digital skills and digital is becoming professionalized in the museums (Parry, R., Eikhof, D. R., Barnes, S.-A., & Kispeter, E., 2018). Anyway, since there is also little evidence of in-house formal and planned training around digital skills or digital literacy, because they are perceived as technical competencies with the result of creating a resistance, the next change to drive is developing digital literacy together with developing organizational structures and investment in digital (Merendino & Meadows, 2021, p.25) and changing stereotyped attitudes towards digital (Newman et al., 2022).

3.1.3 Digital transformation: digital asset preservation

Digital asset preservation of tangible and intangible CH can be understood as both the preservation of digital surrogates, popularly known as "digitization", and the preservation of digitally born resources, namely digital data (Cameron, 2021). The digitization process, digital data gathering, and their restoration in various forms, such as digital libraries or in-person exhibits, are all included in the preservation lifecycle. The task for museums and digital galleries in this changing environment is twofold. After years of digitization, the web has started to fill up with archives and digital galleries that allow people to enjoy CH outside of physical museums and enhance the multimodal fruition of

heritage on-site through interactive digital storytelling and virtual means (Windhager et al., 2019) In this context, efforts have been made in recent years to design a remarkable diversity of interaction and data visualization techniques that have sparked the spread of digital archives with “generous” interfaces that favour serendipitous rather than search-centric exploration of cultural objects (Whitelaw, 2015; Windhager et al., 2019). Hence, the design challenge for museums and digital galleries is twofold in this evolving context. On the one hand, to develop new frameworks and techniques to improve the digitization lifecycle of tangible and intangible CH. On the other, to reflect on the modalities of documentation, conservation, and display of digital objects' “performative natures” and digital data.

3.1.4 Digital transformation: copyright and Creative Commons

The intellectual property assets and the regulations regarding their use are crucial for the development of digital heritage. The European Community took a stride forward in 2012 when the entire dataset of *Europeana*[4] was transferred to the Public Domain, enabling the use, enhancement, and repurposing of the computerized CH of Europe for any uses without copyright limitations (Sanderhoff, 2014). Since then, much research has been done to guarantee that CH resources are accessible, well-organized, and produce high-quality digital works that can be produced and distributed. NFTs (Non-Fungible Tokens), which are non-interchangeable data units that can be saved and traded using blockchain technology and cryptocurrencies, have recently emerged. On the one hand, NFTs technology provides certificates of authentication of digital-born resources, making ownership and trading of digital assets technologically possible (Liddel, 2021). On the other hand, using NFTs brings with it some risks due to the still limited regulation which, for instance, does not clarify how Open GLAM[5] can be turned into NFTs (Valeonti et al., 2021). To establish a solid connection between Creative Commons, OpenGLAM and NFT technology, CH researchers and professionals in the field of design should be informed about the implications of NFTs on museum institutions, how blockchain technology can enhance the in-situ production of CH, and which frameworks and methodologies can be developed to study the development of new business models.

3.1.5 Digital transformation: disruptive technology

How are cultural institutions adopting disruptive and emerging technologies? Cultural and creative industries have always been forerunners in adopting novel technologies to provide visitors with enriched users experiences (Patrickson, 2021). Nevertheless, despite the continuous technological development, museums and cultural institutions tend to be more conservative (Peacock, 2008; Taormina & Baraldi, 2021). According to recent data, digital technologies will contribute to the cultural institution's success in the upcoming three years, but, for the moment, only 28% got revenues out of digital solutions. Furthermore, the most adopted technological solutions are mostly media content, web and mobile applications, and interactive exhibits. Virtual/augmented reality, artificial intelligence, and blockchain are usually pointed at as disruptive and emergent technologies entering the cultural realm. The report confirms that virtual reality, augmented reality, and especially online exhibitions are on the rise (Museum Innovation Barometer 2021). Also, the concept of the digital twin is being translated by the industry to cultural institutions for preservation and curation (Yeom & Woo, 2021).

[4] https://www.europeana.eu/it
[5] https://openglam.org/

Other surveys confirm these data, highlighting a shallow adoption of AI in the cultural realm (Fiorucci et al., 2020); so far, data intelligence has been used to improve the users' experience (Majd & Safabakhsh, 2017). Blockchain technology has being entering the cultural field with NFT – Not fungible tokens (Valeonti et al., 2021), as well as through other interesting experimentations as Decentralized Autonomous Organizations (Catlow & Rafferty, 2022).

3.1.6 Inclusive engagement: cultural inclusivity

Cultural inclusivity has become, following the DEAI (diversity, equity, accessibility, and inclusion) imperative (Cole & Lott, 2019) one of the most relevant change drivers for museums and cultural institutions, representing the bigger challenge to enhance the resourcefulness, resilience and user-centeredness of cultural organisations (Arenghi et al., 2016). Technological advances have been one of the most used tools to improve:

1. accessibility, creating content and activities that can be adapted to various types of visitors with different cultural background and knowledge/competences, up to for users with disabilities (Evett & Tan, 2002; Sorce et al., 2018; Vaz et al., 2018), or cognitive (linguistic, technological literacy etc) barriers (e.g., elderly people) or not “able enough” (e.g., children) (Pisoni et al., 2021).
2. cultural diversity and social cohesion, empowering also vulnerable groups and minorities, such as migrant communities (Cesario et al., 2022) and by a design approach, integrating multicultural storytelling, intercultural dialogue and transcultural practice into the museum experience (Lupo et al., 2014)
3. democratic participation and social action, bringing the museum to be a site of social activism and politic discourse (Lord & Blankenberg, 2015) and creating greater equity and justice within the museum field (White, 2017).

Anyway, technology practices sometimes create barriers for access and inclusion. For instance, scholars argue that as AI technologies can amplify existing gender and racial biases in our society, they can also exhibit disability-based discrimination (Morris, 2020), and only few studies problematize the use of technology in enabling communities in documenting their owned heritage (Graham, 2009). In addition, for a real democratic engagement, a revision of the participatory paradigms is currently occurring (Dore, 2022).

3.1.7 Inclusive engagement: design methods for engagement and cultural outreach

In recent years, the shortcomings in the public budget forced museums to seek new funding sources: this has led many cultural institutions to adopt new models to make the museum and its collections more accessible and oriented to visitors (Camarero & al., 2015). With the pandemic, the sector was even more pushed to explore new ways of reaching out to their audiences (Noble, 2021). Museums, from being collection-centric institutions, are turning to dynamic, community-centric spaces: they are changing from places that preserve cultural assets to dynamic spaces where people can interact with content and dialogue with each other (Lupo & Trocchianesi, 2016). This participatory turn in museums advances a critical aspect of the museum-visitor relationship: visitors have a unique perspective that can inform museum experience and deconstruct notions of museums as the single authority of cultural interpretation (Bertacchini & Morando, 2013). In this context, finding the proper balance between participation, personalization and social engagement through digital experiences is increasingly challenging (Spallazzo, 2016). Co-design and co-creation strategies contribute to subverting this

notion of “authorized heritage discourse” (Petrelli et al., 2021), strongly relying on the “participatory factor” (Falchetti et al., 2021). The literature provides several examples accounting for this transformation of museums: in Avram et al. (2019), a variety of participants shaped the decision-making process, progress, and impact of a project, interweaving many skills; co-design methodologies can be indeed directed by the museum towards managing internal assets and stakeholders, such as the empowerment of the staff and the development of their digital skills (Falchetti et al., 2021). Johnson and Liew (2020) provide engagement-oriented suggestions of how institutions can design their crowdsourcing platforms as to increase online sociability to increase participation to heritage crowdsourcing projects.

3.1.8 New experience rituals: Immersive Extended experiences

The digital transformation in cultural institutions and especially the use of new technological means, are affecting also the experience of the audience. More and more often, cultural institutions use technology to enhance user involvement through the creation of immersive experiences that have the power to activate the visitor’s perception and embodied sensory stimulation. Among technologies adopted, immersive technologies are becoming increasingly common for the influence that they have on user experience, enjoyment, presence, and cognitive, emotional, and behavioural engagement at different levels (Verhulst et al., 2021). Extended Reality (XR) technology may offer remarkable benefits in relation to exhibition enhancement, reconstruction, and creation of virtual museums and exploration (Bekele et al., 2018). Indeed, XR technologies are often defined by scholars providing specific characteristics, such as sensory involvement (Hsieh et al., 2018), relevant to the creation of multisensory experiences (Marto et al., 2021) and user engagement related to interactive real-time simulations (Bisson et al. 2007, McCloy & Stone, 2001). Although the use of XR offers different advantages, it also introduces challenges and limitations faced by heritage professionals (Cerquetti, 2018; Menegaki, 2021) that can be associated with both a lack of solid strategic framework and specific design processes, lack of specialized digital department and the related financial issues for introducing such technologies. Given that, some cultural institutions and sites are still being at the phase of trial-and-error to integrate immersive technologies (Shehade & Stylianou-Lambert, 2020) or underline the risk that new technologies can have in favour of enjoyment purposes over educational ones, referring for example to a “Disneyfication” of the museum’s offerings (Balloffet et al., 2014; Cerquetti, 2016; Bello & Mohamed, 2018).

3.1.9 New experience rituals: connectedness

Digital technologies can reshape cultural visit in terms of embodiment and human connection. Especially during the pandemic, between 2020 and 2021, the impossibility of welcoming visitors to cultural venues made online visits flourish (King et al., 2021). The most critical aspects that soon emerged relate to the lack of embodiment and human connection. Embodiment in cultural visits has been largely studied (Rahaman, 2018), reflecting specifically on the embodiment of digital heritage, formalizing categories and providing guidelines (Johnson, 2008; Kenderdine, 2015). However, distance visits remain at a superficial level of embodiment, relying on clicking, scrolling and watching videos (King et al., 2021). Some studies started to address human connection in remote visits, through the issue in VR environments, focusing on spatial presence, situational interest and behavioural attitudes, suggesting storytelling and gamification (Cheng, 2021) or blending remote and physical visits (Pisoni et al., 2019). Digital technologies are also employed to enhance the physical visit through personalization of tangibles (Not & Petrelli, 2018) or with AR/XR (Marto et al., 2022).

3.1.10 New experience rituals: sensitive heritage

Studies in museums and art galleries emphasize the stimulation of multiple human senses (Obrist et al., 2017; Davis & Thys-Senocak, 2017) to create multisensory experiences that enhance emotional engagement, especially abstract art representations (Vi et al., 2017), and provide visitors with a meaningful, embodied understanding of the cultural artifacts.
Visual and auditory stimuli are usually the most frequently integrated, but there is an increasing attitude toward trying to stimulate all five human senses. Some studies introduce in the CH field also haptic stimulation created, for example, through devices that produce vibrotactile stimuli (Jung et al., 2019; Pursey & Lomas, 2018), while is more common the implementation of fragrances by combining olfactory stimulation with other visual or auditory technological inputs (Claisse et al., 2018), or with tangible interactions (Lai, 2015). In fact, smell is proven to have a key role in recollecting personal memories and arousing emotions (Miotto, 2016), and the integration of appropriate scents is demonstrated to enhance the visitor's memories of a visited museum (Spence, 2020). It is also underlined that olfactory involvement is more effective if it relates to the object of the representation, creating a unique stimulus, rather than using scents unrelated to the artifact (Spence, 2020). The smell integration is also used to help reduce the distance between the artifact and the visitor, especially if the object is placed inside a glass case to ensure its conservation (Chu et al., 2016).

3.1.11 New experience rituals: entertainment

Museums and other CH institutions have evolved regarding the change of the public, turning from places of aesthetic contemplation into entertainment places, including commercial areas, such as restaurants and shops. Aesthetic contemplation has given way to sensory experience, gradually transforming museums into sensescape-type and the new role of entertainment, according to the change in the audience's taste (Marinescu, 2018). So educational/cultural activities become closely related to commerce and entertainment a new process of 'edutainment', based on the concept that 'learning is fun' (Aalst & Boogaarts, 2002). Edutainment experiences the new operational paradigms for heritage institutions and, by technology, can offer location-based entertainment and E-visitor attractions, including on-set visualizations for the TV/movie industry (Haddad, 2014). In addition, the field of CH has positively rated the idea of using the game for educational learning, implementing the cultural offer with Serious Games and Gamification, which use game design elements to engage users with the aim of an improvement of learning outcomes (Andreoli et al., 2017). Nowadays, ICT technologies have shown multiple potentialities in heritage communication and safeguard, offering innovative features and using different digital channels in various ways (Tzima et al., 2021). Video games for CH can be considered an effective innovative tool to transmit knowledge and culture, since they can integrate art with storytelling and digital technology (Di Paola et al., 2019).

3.2 Users' needs and behaviors

As described in the methodology, the stakeholder system has been mapped as a constellation of actors inside and outside cultural institutions, and, in parallel, the value chain has been reconstructed and articulated in functions that go beyond the experience of end users.

Figure 6 is the result of the cross-referencing of the four functions with the stakeholders coexisting on each function, the relevant issues identified by the literature review and the structure of the value chain. The Figure shows how the relevant issues emerged in the literature have been problematized considering their positioning along the value chain and the stakeholders they impact on, generating

the macro-themes in the table. For each macro-theme, the investigation opened further issues and problems and allowed to identify the Changing Heritage Drivers for design actions to intervene on.

MACRO-FUNCTIONS	MACRO-THEMES	CHANGING HERITAGE DRIVERS	STAKEHOLDERS INVOLVED
Infrastructure & Management	1) New business opportunities for culture through digital	• which assets museums have available to create economic returns. • which fundraising activities are enabled by digital technology and whether they are being utilized.	ICT team, Curators, Directors Foundations (e.g. Cariplo), Banks
	2) Digital support for decision-making processes in museums	• whether and how technological tools can facilitate decision-making processes (e.g. digital assessment frameworks).	ICT team, Curators, Directors
	3) Skills needed to support digital transformation	• how to manage processes of digital upskilling. • which skills are considered necessary and lacking (new roles or upskilling).	ICT team, Curators, Directors Osservatorio Polimi, Companies active in the Digital Transformation (e.g., Accenture, Intellera)
	4) Impact assessment of digital initiatives	• the perceived importance of evaluation. • which indicators are used.	ICT team, Curators, Directors, Education managers Companies active in the Digital Transformation (e.g., Accenture, Intellera), Experts in Impact Assesment (e.g., ROMA3)
Infrastructure & Management Services	5) Use of data intelligence systems on data collected within Institutions	• why, despite having extensive collections, few institutions use this data.	ICT team, Curators, Directors Tech Companies/research centers specialized in AI (ENEA, CNR)
Infrastructure & Management Services Preservation	6) Use of Non-fungible tokens (NFTs) in museum contexts	• whether technology is known and understood. • whether NFT technology is perceived as an opportunity or a threat. • whether it is perceived in opposition to OpenGLAM approaches.	Curators, Directors Osservatorio Polimi, Companies active in the field (e.g. Cinello)
Preservation	7) Documentation and preservation of intangible, evolving, performing assets	• how preservation processes for such heritage can create engagement and audience activation.	ICT team, Curators digital exhibitions and virtual museums (without physical space) Designers of exhibit installations, User Interface designers, Video designers
Audience development	8) Use of participatory approaches to museum design	• whether institutions understand Participatory approaches as used by our department. • whether institutions are ready to adopt these approaches.	ICT team, Curators, Directors, Education managers Companies active in the field (e.g. BAM), Fablab (e.g. Muse)
	9) Use of approaches that combine education and entertainment in the cultural sphere	• the knowledge and use of edutainment approaches by Institutions. Interesting also in relation to the type of museum (art, science, etc.). • whether the term "edutainment" is outdated or still relevant. • the perceived importance of these approaches by Institutions.	ICT team, Curators, Directors, Education managers Tech provider, CCIs
	10) Integration of multisensory stimulation in cultural experiences	• whether institutions feel the need to include multisensory stimuli. • whether multisensoriality is considered an added value (especially in relation to the sense of presence and immersion during experiences) by Cultural Institutions	ICT team, Curators, Directors, Education managers CCIs e XR developers (es Hevolus, Anotherreality, Brainstorm Multimedia)
	11) Create physical, remote or hybrid cultural experiences	• the perceived importance of institutions in creating remote or hybrid experiences compared to physical experiences. • the need for adopting such modes of use.	ICT team, Curators, Directors, Education managers CCIs e XR developers (es Hevolus, Anotherreality, Brainstorm Multimedia)
	12) Using Extended Reality (XR) technologies to create cultural experiences	• whether the adoption of technologies is perceived as an advantage by Institutions in improving the user experience. • what factors prevent institutions from adopting such technologies (few adopt them).	ICT team, Curators, Directors, Education managers International Experts (es. ViMM project)
	13) Integration of digital technologies to promote accessibility and inclusion in the cultural sphere	• how the use of digital technologies to promote real accessibility and inclusion is perceived. • how cultural biases and technological gaps are overcome by cultural Institutions.	ICT team, Curators, Directors, Education managers
	14)Use of gamification techniques in creating cultural experiences	• how gamification techniques are integrated into cultural experiences. • whether gamification is considered a stable and continuous paradigm of use.	ICT team, Curators, Directors, Education managers

Infrastructure & Management
Services
Preservation
Audience development

Internal stakeholders
External stakeholders

Figure 6. scheme showing the macro-themes, changing heritage drivers, stakeholders and virtuous example identified in relation to the four macro-functions.

The following paragraph aims at explaining how the macro-themes have generated the Changing Heritage Drivershow they impact on stakeholders and what are possible future developments. For length opportunities, the discussion privileges the macro-functions that, as stated earlier in the text, present more design-related issues: audience development and infrastructure & management): among them, some of the macro-themes have been taken as examples and illustrated by adding references to virtuous examples.

Over the infrastructure & management function of institutions, one aspect coming from the literature is the slow gradualness of organizational changes driven by technologies, despite the rapid evolution of digital tools and the evident urgency for museums to develop their operational, organizational, and strategic dimension. An example in this sense is the low adoption of impact assessment of digital initiatives (n. 4 in Figure 6). Drivers here are aimed to understand the importance of evaluating the impact of digital initiatives and the reasons why, despite many cultural institutions collect digital data, there are very few applications of data intelligence. Consequently, design actions would identify the indicators to be used for the evaluation and activate the dialogue between internal stakeholders (ICT team, curators, directors, education managers) and external ones (companies active in the Digital Transformation). A valuable case study is the Empathetic Museu[6] initiative assessment tool proposed to help organizations introduce empathy in their activities to better reflect and represent the values of their communities. In the DH change, similar models could be used to assess the impact of digital initiatives. Again, another relevant macro-theme for the infrastructure & management function concerns the digital skills needed to support the ongoing digital transformation (n. 3 in Figure 6). Change will be driven by the understanding of which are the skills -new or updated- needed and lacking, and of how internal stakeholders like ICT team, curators, directors can manage processes of digital upskilling.

We have seen in the literature how, despite the increasing technological development, museums tend to be conservative and reticent in welcoming disruptive technologies even when they concern functions unrelated to audience development, like infrastructure & management, preservation, and services. It is the case of NFTs (n. 6 in Figure 6), where the drivers emerged with the user analysis intend to deepen the understanding of whether the technology is perceived as an opportunity or a threat by key stakeholders inside institutions such as curators or directors. The debate around NFTs, indeed, still raises ethical and economic questions on the ownership of pieces and their reproduction. Ahead of the debate, the possible change will be driven by the improvement in the level of knowledge about NFTs, and by the role taken by the stakeholders outside institutions in moving this knowledge forward. A virtuous example in this sense it is Reasoned Art[7], an Italian startup dedicated to Crypto Art, digital art certified by NFT technology and exchanged on blockchain.

Among the four macro-functions, audience development is the one related with the largest number of macro themes, and the result is a greater scope for design intervention. Connected to what emerged in the literature concerning new experience rituals, the analysis highlighted a wide-open discussion around the dichotomy between the physical and the digital dimension (n. 11 in Figure 6),

[6] http://empatheticmuseum.weebly.com/maturity-model.html

[7]

the in-presence and the remote visits. The research finds space of intervention for design in understanding the inclination of institutions and end users towards fully physical, digital, or hybrid experiences. Design approaches can work with internal and external (CCIs e XR developers) stakeholders to investigate the boundaries of the diverse dimensions and to find fertile ground for them to nurture each other, e.g. by generating multisensorial systems in which the digital can favor the immersion and the sense of presence perceived by visitors during physical events. Concerning the remote visit concept, the British Museum represents an interesting example[8], which allows exploring more than 60 galleries from home.

Following this path, despite the integration of multisensorial stimuli (n. 10 in Figure 6) offers to cultural institutions several possible scenarios for the evolution of physical and remote experiences, the user analysis questioned the perception and the level of openness to these tools, and whether internal stakeholders (ICT teams, curators, directors, education managers) -and who among them- feel the need to include them when creating new experiences. The answers depend also on the ability of external stakeholders (CCIs e XR developers) to promote digital tools and to facilitate their spread. A virtuous example is represented by the project "Cosmos Within Us", created by the Satore Studio[9]. Which consists of a storytelling experiment that combines immersive technology and multisensory stimulation integrating scent and touch.

The literature indicates cultural inclusivity as one of the most relevant change drivers and challenges for cultural institutions, with digital technologies as a tool to improve accessibility, cultural diversity, and democratic participation. To activate this change, we point out as drivers the understanding of the real impact of digital technology in promoting and achieving cultural inclusivity (n. 13 in Figure 6), the level of integration reached so far, and moreover the existing cultural biases and technological gaps that prevent a smooth shift and how the internal stakeholders are acting to overcome them. Among the others, an example of inclusive engagement is given by the social cooperative ABCittà[10]. Specifically, the objective has been to build an inclusive process capable of promoting good information on technical and regulatory aspects by consulting children, young people, and adults and setting up local actions to bring into play administrators, technicians, consultants and citizens in an open and transparent debate on the collective interests to constitute a strategic vision (Boano & Astolfo, 2016).

Museums are changing their status and turning to dynamic spaces where people can interact with content, dialogue with each other, participate, and co-design experiences. The use of participatory approaches to museum design (n. 8 in Figure 6) is another relevant macro-theme related to audience development, where the changing drivers are the transfer of the participatory approaches used in the Department of Design, Politecnico di Milano, and the understanding of whether internal (ICT teams, curators, directors, education managers) and external stakeholders (companies active in the field, fablabs, etc.), are ready to adopt them; a virtuous example is represented by the meSch project. This 4-year EU-funded project follows the principles of co-design, with the participation of different

[8] https://www.britishmuseum.org/blog/how-explore-british-museum-home
[9] https://satorestudio.com/portfolio_page/cosmos-within-us/
[10] http://abcitta.org/

stakeholders by adopting a Do-It-Yourself approach. The project aimed at co-designing novel platforms for creating tangible exhibits at heritage sites by integrating technology[11].

4 Conclusions

Since the Polimi Design Think Tank is aiming at creating "innovation convergences" between academic research and cultural institutions, the next step is to create a direct dialogue with some stakeholders. This will be pursued through a survey (ongoing) and a focus group based on the DELPHY research method.

Currently, the survey is targeting a total of about 40 subjects referring to the following categories, as individuated in the value chain mapping: museum curator, museum/gallery/museum institution director, ICT services manager, digital archivist, museum designer, exhibition designer, multimedia/interactive installation designer, expert of emerging technologies for museums, digital communication designer, digital content creator, journalist.

The survey questions are based on three thematic groups of questions, deriving from previous studies both about literature review and on user needs (see Figures 2, 6 and discussion). Therefore, the questions have tried to problematize the issues in relation to the stakeholders, and their understanding and competencies on the topics. The survey is currently processing the results, which will be useful for organizing the forthcoming focus group.

As an intermediate output of the research, with this paper, we aim at consolidating the results gathered in the first phases of the TT, providing the design community (academics and professionals working in CH and museums) with a theoretical contribution on the most possible updated and extensive knowledge about digital changes and challenges of heritage and museums based on a design perspective[12].

Being aware of the fast obsolescence and impetuous changes of technological advancement, and looking for a design-based actionable knowledge to support the actors working in the heritage field, the overview has not been conducted with a technology-driven approach and instead deliberately selecting (as accurately as possible), within a recent year span, the most relevant streams, themes and functions that are informed (or can be) by a design approach: this resulted in excluding (among the other) areas such as restoration or in downsizing preservation.

Thus, the review of the literature and the mapping of the constellation of stakeholders provides solid evidence that digital technologies are transversal tools throughout the whole value chain, and the current and most fruitful changing heritage drivers are the complex issues emerging from the convergence in the value chain stages of digital opportunities and stakeholders' interests and competences: design can drive the transformation in orienting that convergences and humanizing and enculturing technologies.

[11] https://www.mesch-project.eu/

[12] New publications may have been released since the literature review closed in June 2022.

In this framework, beyond the acknowledged design expertise in enhancing visitor experiences (which is clearly demonstrated by both the literature review in new hybrid experience rituals and inclusive engagement based on new technologies like XR, and by the value chain function audience development) promising signals prove that the emerging role of design in backtracking the value chain is getting acknowledged and acquainted. So, among the design phenomena that built the collective discourse of design (Deserti, 2013), next to visible and shared manifestations, like the design of innovative participatory, creative and inclusive cultural experiences in the end-user side of the value chain (Lupo, 2021; Mason & Vovoula, 2021), is now evident and acknowledged that new challenges and drivers are bringing design to the upper side of the value chain and in relation with different stakeholders to promote in-deep changes in cultural institutions (e.g., management of digital transformation and organizational change). Interesting niches of opportunities come also from the function of preservation, where the preservation of digital or intangible assets needs design expertise and approaches; or in the one of innovative services by a culture driven use of disruptive technologies like data intelligence or NFT.

Therefore, even if often the easiest gateway for introducing design competences in museums is the enhancement of the realm of the visitor experience, it is when design bridges the innovation at the end-user side with the one at the management level that the adoption of digital technologies generates deep, long term and meaningful changes for museums, paving the way for future development. In this scenario, the museum stakeholder constellation engagement, and their upskilling, as well as a full acknowledgment of the most advanced design competences, are crucial achievements to establish a profitable collaboration among academic research and digital innovation in the museum sector.

Contributorship

The authors confirm contribution to the present paper as follows: study conception and design: Lupo, E., Spallazzo, D.; data collection, for Literature Review part: Lupo, E.; Carmosino, G.; Gobbo, B.; Spadoni, E.; Spallazzo, D.; Rubino, F.; data collection for the User Analysis section: Lupo, E.; Motta, M.; Mauri, M.; Parente, M.; Spadoni, E.; analysis and interpretation of results for the Literature Review section: Lupo, E.; Carmosino, G.; Spadoni, E.; Rubino, F.; analysis and interpretation of results for the User Analysis section: Motta, M.; Spadoni, E.; data visualization and graphics: Gobbo, B.; draft manuscript preparation: Lupo, E.; Carmosino, G.; Gobbo, B.; Motta, M.; Mauri, M.; Parente, M.; Spadoni, E.; Spallazzo, D.; Rubino, F. All authors reviewed the results and approved the final version of the manuscript.

References

Aalst, I. van, & Boogaarts, I. (2002). From Museum to Mass Entertainment: The Evolution of the Role of Museums in Cities. European Urban and Regional Studies. https://doi.org/10.1177/096764200200900303 3

AA.VV. (2021). *Next Generation Culture: Tecnologie digitali e linguaggi immersivi per nuovi pubblici della cultura*. Marsilio Editori spa.

Agostino, D. & Costantini, C. (2021), "A measurement framework for assessing the digital transformation of cultural institutions: the Italian case", Meditari Accountancy Research, Vol. 30 No. 4, pp. 1141-1168. https://doi.org/10.1108/MEDAR-02-2021-1207

Alshawaaf, N., & Lee, S. H. (2021). Business model innovation through digitisation in social purpose organisations: A comparative analysis of Tate Modern and Pompidou Centre. Journal of Business Research, 125, 597–608. https://doi.org/10.1016/j.jbusres.2020.02.045

Andreoli, R., Corolla, A., Faggiano, A., Malandrino, D., Pirozzi, D., Ranaldi, M., Santangelo, G., & Scarano, V. (2017). A Framework to Design, Develop, and Evaluate Immersive and Collaborative Serious Games in

Cultural Heritage. Journal on Computing and Cultural Heritage, 11, 1–22. https://doi.org/10.1145/3064644
Arenghi, A., Garofolo, I., Sørmoen O., (eds) (2016) Accessibility as a Key Enabling Knowledge for Enhancement of Cultural Heritage. FrancoAngeli, Milano
Avram, G., Ciolfi, L., Maye , L. (2020). Creating tangible interactions with cultural heritage: lessons learned from a large scale, long term co-design project. CoDesign, 16:3, 251-266, https://doi.org/10.1080/15710882.2019.1596288
Balloffet P., Courvoisier F.H., Lagier J. (2014). From Museum to Amusement Park: The Opportunities and Risks of Edutainment, «International Journal of Arts Management», 16, n. 2, pp. 4-18.
Bello R.W., Mohamed A.S. (2018). Impact of technology on traditional museum collection storage and management, «International Journal of Computer Science and Mobile Computing», 7, n. 11, pp. 46-51.
Bekele MK, Pierdicca R, Frontoni E, Malinverni ES, Gain J. A survey of augmented, virtual, and mixed reality for cultural heritage. ACM J Comput Cult Herit 2018;11(2):7 (1–36). https://doi.org/10.1145/3145534
Bertacchini, E., Morando, F. (2013). The Future of Museums in the Digital Age: New Models for Access to and Use of Digital Collections, International Journal of Arts Management , WINTER 2013, Vol. 15, No. 2, Special Issue: Digital Revolution in Arts and Cultural Organizations (WINTER 2013), pp. 60-72
Bertola P. Texeira, J.C. (2003). Design as a knowledge agent: How design as a knowledge process is embedded into organizations to foster innovation. Design Studies, 24 (2): 181-194 https://doi.org/10.1016/S0142-694X(02)00036-4
Bisson, E., Contant, B., Sveistrup, H., & Lajoie, Y. (2007). Functional balance and dual-task reaction times in older adults are improved by virtual reality and biofeedback training. Cyberpsychology & behavior, 10(1), 16-23. https://doi.org/10.1089/cpb.2006.9997
Boano, C., & Astolfo, G. (2016). I quaderni, 08 coscienza urbana. Journal of urban design and planning, ISSN: 1973-9702
Camarero, C., Garrido, M. J., & Vicenteb, E. (2015). Achieving effective visitor orientation in European museums. Innovation versus custodial. Journal of Cultural Heritage, 228-235. https://doi.org/10.1016/j.culher.2014.05.006
Cameron, F.R. (2021). The Future of Digital Data, Heritage and Curation: in a More-than-Human World (1st ed.). Routledge. https://doi.org/10.4324/9781003149606
Catlow, R., Rafferty, P. (2022). Radical Friends: Decentralised Autonomous Organisations and the Arts, Torque Editions 2022
Cerquetti, M. (2016). More is better! Current issues and challenges for museum audience development: a literature review. *Current Issues and Challenges for Museum Audience Development: A Literature Review (December 1, 2016). JOURNAL OF CULTURAL MANAGEMENT & POLICY*, *6*(1).
Cerquetti, M. (2018). The importance of being earnest. Enhancing the authentic experience of cultural heritage through the experience-based approach. The Experience Logic as a New Perspective for Marketing Management: From Theory to Practical Applications in Different Sectors, 149-168. https://doi.org/10.1007/978-3-319-77550-0_8
Cesário, V., Acedo, A., Nunes, N., Nisi, V. (2022) Promoting Social Inclusion Around Cultural Heritage Through Collaborative Digital Storytelling. In: Wölfel, M., Bernhardt, J., Thiel, S. (eds) ArtsIT, Interactivity and Game Creation. ArtsIT 2021. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 422. Springer, Cham. https://doi.org/10.1007/978-3-030-95531-1_17
Claisse, C., Petrelli, D., Dulake, N., Marshall, M. T., & Ciolfi, L. (2018, October). Multisensory interactive storytelling to augment the visit of a historical house museum. In 2018 3rd Digital Heritage International Congress (DigitalHERITAGE) held jointly with 2018 24th International Conference on Virtual Systems & Multimedia (VSMM 2018) (pp. 1-8). IEEE. doi: 10.1109/DigitalHeritage.2018.8810099.
Cheng, K. H. (2021). The structural relationships among spatial presence, situational interest and behavioral attitudes toward online virtual museum navigation: a PLS-SEM analysis. Library Hi Tech. https://doi.org/10.1108/lht-09-2021-0301
Chu, J. H., Harley, D., Kwan, J., McBride, M., & Mazalek, A. (2016). Sensing History: Contextualizing Artifacts with Sensory Interactions and Narrative Design. Proceedings of the 2016 ACM Conference on Designing Interactive Systems, 1294–1302. https://doi.org/10.1145/2901790.2901829
Cole, J. B., & Lott, L. L. (Eds.). (2019). Diversity, equity, accessibility, and inclusion in museums. American Alliance of Museums. Lanham, MD: Rowman & Littlefield. https://doi.org/10.33137/ijidi.v4i1.33047

Davis, L., & Thys-Şenocak, L. (2017). Heritage and scent: Research and exhibition of Istanbul's changing smellscapes. *International Journal of Heritage Studies*, *23*(8), 723-741. https://doi.org/10.1080/13527258.2017.1317646

Deserti, A. (2013). I Design Phenomena. In A. Penati. (Ed.), *È il Design una Narrazione? Design e Narrazioni*. (pp. 49-62). Milano: Mimesis Edizioni.

Di Paola, F., Inzerillo, L., & Alognaa, Y. (2019). A gaming approach for cultural heritage knowledge and dissemination. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. https://doi.org/10.5194/isprs-archives-XLII-2-W15-421-2019

Dore, M. (2022) Designing With or Against Institutions? Dilemmas of Participatory Design in Contested Cities, *Design and Culture*, 15:1, 27-47, https://doi.org/10.1080/17547075.2022.2103957

European Commission (EC), Directorate-General for Education, Youth, Sport and Culture, Hoelck, K., Engin, E., Airaghi, E., et al. (2017). Mapping the creative value chains: a study on the economy of culture in the digital age: final report, Publications Office, https://data.europa.eu/doi/10.2766/868748

Esposito, P., Braga, A., Sancino, A., Ricci, P. (2021). The strategic governance of the digital accounting environment: insights from the virtual museums, Meditari Accountancy Research. https://doi.org/10.1108/MEDAR-03-2020-0837.

Evett, L., & Tan, Y.K. (2002). Talk your way round—A speech interface to a virtual museum. Disability and Rehabilitation. 24:11-12, 607–612. https://doi.org/10.1080/09638280110111379

Falchetti, E., Migone, P., Da Milano, C., & Guida, M. F. (2021). Digital storytelling and lifelong learning education in informal contexts: the memex project. https://doi.org/10.36315/2021end065.

Fleming, T. (2021), Museum revisited/Italy. Summary report. https://www.britishcouncil.it/en/programmes/arts/museums/museums-revisited

Fiorucci M., Khoroshiltseva M., Pontil M., Traviglia A., Del Bue A., James S., (2020) Machine Learning for Cultural Heritage: A Survey, Pattern Recognition Letters, 133, 102-108. https://doi.org/10.1016/j.patrec.2020.02.017

Freeman, A., Adams Becker, S., Cummins, M., McKelroy, E., Giesinger, C. & Yuhnke, B. (2016). NMC Horizon Report: 2016 Museum Edition. Austin, Texas: The New Media Consortium. Retrieved April 14, 2023 from https://www.learntechlib.org/p/182007/.

Gretchen et al. (2019). The Empathetic Museum: A New Institutional Identity. Curator: The museum Journal, 62(4): 505-526 https://doi.org/10.1111/cura.12335

Graham, L. R. (2009) Problematizing of Technologies for Documenting Intangible Culture: Some Positive and Negative Consequences in Silverman, H., & Ruggles, D. F. (Eds.). (2009). Intangible Heritage Embodied. Springer New York. https://doi.org/10.1007/978-1-4419-0072-2

Haddad, N. A. (2014). Heritage Multimedia and Children Edutainment: Assessment and Recommendations. Advances in Multimedia, 2014, 579182. https://doi.org/10.1155/2014/579182

Hausmann, T., Hackney, S. (2021). Market Analysis and Opportunity Assessment of Museum Capacity Building Programs. (IMLS Award Number MG-00-19-0073-19). Institute of Museum and Library Services. Washington, D.C.

Hsieh, C. C., Kin, P. S., Hsu, W. C., Wang, J. S., Huang, Y. C., Lim, A. Y., et al. (2018). The Effectiveness of a Virtual Reality-Based Tai Chi Exercise on Cognitive and Physical Function in Older Adults with Cognitive Impairment. Demen. Geriatr. Cogn. Disord. 46 (5–6), 358–370. https://doi.org/10.1016/ j.physio.2015.03.3418

Johnson, E., Liew, C. L., (2020). Engagement-oriented design: a study of New Zealand public cultural heritage institutions crowdsourcing platforms, OIR 44,4, 887-912. https://doi.org/10.1108/OIR-10-2019-0329

Johnson, M. (2008). The Meaning of the Body: Aesthetics of Human Understanding. University of Chicago Press.

Jung, D. H., Kim, J., Lee, J. G., Yang, H. J., & Ryu, H. (2019). Lessons Learned from an Auditory-vibrotactile Sensory Experience in the Museum. Proceedings of the 2019 ACM International Conference on Interactive Surfaces and Spaces, 373–378. https://doi.org/10.1145/3343055.3360754

Kamaritou, V., Kamaritou, M., Kitsios, F. (2021). Digital Transformation Strategy Initiative in Cultural Heritage: The Case of Tate Museum. https://doi.org/10.1007/978-3-030-73043-7_25

Kenderdine, S. (2015). Embodiment, Entanglement, and Immersion in Digital Cultural Heritage. In A New Companion to Digital Humanities (pp. 22–41). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118680605.ch2

King, E., Smith, M. P., Wilson, P. F., & Williams, M. A. (2021). Digital Responses of UK Museum Exhibitions to the COVID-19 Crisis, March – June 2020. Curator: The Museum Journal, 64(3), 487–504. https://doi.org/10.1111/cura.12413

Lai, M. K. (2015, July). Universal scent blackbox: Engaging visitors communication through creating olfactory experience at art museum. In Proceedings of the 33rd Annual International Conference on the Design of Communication (pp. 1-6). https://doi.org/10.1145/2775441.2775483

Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends, Technovation 2020 vol. 92-93. https://doi.org/10.1016/j.technovation.2017.12.004

Liddell F., (2021), Building Shared Guardianship through Blockchain Technology and Digital Museum Objects, Museum and Society, Vol 19, No 2 (2021), Special Issue: Digital (and) Materiality in Museum, DOI: https://doi.org/10.29311/mas.v19i2.3495

Lord, G. D. and Blankenberg, N. (2015), Cities, Museums and Soft Power, The AAM Press, Washington. https://doi.org/10.1080/10253866.2016.1236254

Lupo, E., & Trocchianesi, R. (2016). Design Envisioning for Museums: the experience at Museo Diocesano. In *Designing Multivocal Museum. Intercultural Practices at Museo Diocesano* (pp. 9-28). Politecnico di Milano.

Lupo, E., Parrino, L., Radice, S., Spallazzo, D., & Trocchianesi, R. (2014). Migrations and multiculturalism: A design approach for cultural institutions. In P. Innocenti (Ed.), Migrating Heritage: Experiences of Cultural Networks and Cultural Dialogue in Europe (pp. 65–77). Ashgate.

Lupo, E., (2021). Design and innovation for the Cultural Heritage. Phygital connections for a Heritage of proximity. AGATHÓN –International Journal of Architecture, Art and Design, 10, 186-199. https://doi.org/10.19229/2464-9309/10172021

Majd, M., & Safabakhsh, R. (2017). Impact of machine learning on improvement of user experience in museums. 2017 Artificial Intelligence and Signal Processing Conference (AISP), 195–200. https://doi.org/10.1109/AISP.2017.8324080

Manzini, E. (2004). Design Multiverso. In E. Manzini & P. Bertola (Eds.), *Design multiverso. Appunti di fenomenologia del design*. edizioni polidesign.

Mason, M., & Vavoula, G. (2021). Digital Cultural Heritage Design Practice: A Conceptual Framework. The Design Journal, 24(3), 405–424. https://doi.org/10.1080/14606925.2021.1889738

Marinescu, A. (2018). The museum between education and entertainment: The role of the museum according to the target public. https://doi.org/10.15406/sij.2018.02.00047

Marto, A., Gonçalves, A., Melo, M., & Bessa, M. (2021). A survey of multisensory VR and AR applications for cultural heritage. Computers & Graphics. https://doi.org/10.1016/j.cag.2021.10.001

McCloy, R., and Stone, R. (2001). Virtual Reality in Surgery. Bmj 323 (7318), 912–915. https://doi.org/10.1136/bmj.323.7318.912

Merendino, A. and Meadows, M. (2021). *The Museums Sector: Be Digital to Be Strategic*. Coventry University. On line at https://www.coventry.ac.uk/research/research-directories/completed-projects/2021/be-digital-to-be-strategic-in-the-museums-sector-surviving-the-pandemic/

Menegaki, A. N. (2022). New Technologies in Hotels and Museums: Supply-side Perceptions with Education Implications for Managers and Curators. Journal of the Knowledge Economy, 13(4), 2935-2956. https://doi.org/10.1007/s13132-021-00849-z

Ministero della Cultura (Ed.) (2023), Piano nazionale di digitalizzazione del patrimonio culturale 2022-2023 versione 1.1, https://digitallibrary.cultura.gov.it/il-piano/

Miotto, L. (2016, October). Using scents to connect to intangible heritage: Engaging the visitor olfactory dimension: Three museum exhibition case studies. In 2016 22nd International Conference on Virtual System & Multimedia (VSMM) (pp. 1-5). IEEE. https://doi.org/10.1109/VSMM.2016.7863208

Morris, M.R. AI and Accessibility: A Discussion of Ethical Considerations. In Communications of the ACM Vol. 63, Issue 6 (June 2020), pp 35–37 https://doi.org/10.1145/3356727.

Newman T., Beetham H., Church S. (2022), DASH-Digital Attitudes and Skills for Heritage survey results 2021, The National Lottery Heritage Fund

Noble, K. (2021), Challenges and Opportunities: Creative Approaches to Museum and Gallery Learning during the Pandemic. Int J Art Des Educ, 40: 676-689. https://doi.org/10.1111/jade.12380

Not, E., & Petrelli, D. (2018). Blending customisation, context-awareness and adaptivity for personalised tangible interaction in cultural heritage. International Journal of Human-Computer Studies, 114, 3-19. https://doi.org/10.1016/j.ijhcs.2018.01.001

Obrist, M., Gatti, E., Maggioni, E., Vi, C. T., & Velasco, C. (2017). Multisensory experiences in HCI. IEEE MultiMedia, 24(2), 9-13. https://doi.org/10.1109/MMUL.2017.33
Olga Tykhonova & Sofia Widmann (Eds.). (2021). Museum Innovation Barometer 2021. Museum Booster.
Parry, R. (2013). The end of the beginning: Normativity in the postdigital museum. *Museum Worlds*, *1*(1), 24-39.
Parry, R., Eikhof, D. R., Barnes, S.-A., & Kispeter, E.. (2018). Mapping the Museum Digital Skills Ecosystem - Phase One Report (Version 1). University of Leicester. https://hdl.handle.net/2381/41572
Patrickson, B. (2021). What do blockchain technologies imply for digital creative industries? Creativity and Innovation Management, 30(3), 585–595. https://doi.org/10.1111/caim.12456
Peacock, D. (2008) Making Ways for Change: Museums, Disruptive Technologies and Organisational Change, Museum Management and Curatorship, 23:4, 333-351. https://doi.org/10.1080/09647770802517324
Penati, A. (2004). Design come motore di innovazione di sistema. In E. Manzini & P. Bertola (Eds.), *Design multiverso. Appunti di fenomenologia del design*. edizioni polidesign.
Perry, D. L. (2012). What makes learning fun?: principles for the design of intrinsically motivating museum exhibits. Rowman Altamira.
Petrelli, D., Ciolfi, L., & Avram, G. (2021). Envisioning, Designing and Rapid Prototyping Heritage Installations with a Tangible Interaction Toolkit. Human- Computer Interaction. https://doi.org/10.1080/07370024.2021.1946398
Pisoni, G., Díaz-Rodríguez, N., Gijlers, H., Tonolli, L. (2021) Human-Centered Artificial Intelligence for Designing Accessible Cultural Heritage. Applied Sciences, 11(2):870. https://doi.org/10.3390/app11020870
Porter, M. E. (2006, April). Strategy for museums. In Presentation at the American Associations of Museums Conference, Boston.
Pisoni, G., Daniel, F., Casati, F., Callaway, C., & Stock, O. (2019, December). Interactive remote museum visits for older adults: an evaluation of feelings of presence, social closeness, engagement, and enjoyment in an social visit. In 2019 IEEE International Symposium on Multimedia (ISM). https://doi.org/10.1109/ISM46123.2019.00023
Pursey, T., & Lomas, D. (2018). Tate Sensorium: An experiment in multisensory immersive design. The Senses and Society, 13(3), 354-366. https://doi.org/10.1080/17458927.2018.1516026
Rahaman, H. (2018). Digital heritage interpretation: A conceptual framework. Digital Creativity, 29(2–3), 208–234. https://doi.org/10.1080/14626268.2018.1511602
Rampino, L. (2018). Evolving Perspectives in Product Design: From Mass Production to Social Awareness. FrancoAngeli.
Sacco, P. L., Ferilli, G., & Tavano Blessi, G. (2018). From culture 1.0 to culture 3.0: Three socio-technical regimes of social and economic value creation through culture, and their impact on European Cohesion Policies. Sustainability, 10(11), 3923. https://doi.org/10.3390/su10113923
Sanderhoff, M. (2014). Sharing is Caring: Åbenhed og deling i kulturarvssektoren. Statens Museum for Kunst. http://sharingiscaring.smk.dk
Shehade, M., & Stylianou-Lambert, T. (2020). Virtual reality in museums: Exploring the experiences of museum professionals. Applied sciences, 10 (11), 4031. https://doi.org/10.3390/app10114031
Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research. 104. 333-339. https://doi.org/10.1016/j.jbusres.2019.07.039.
Sorce, S.; Gentile, V.; Oliveto, D.; Barraco, R.; Malizia, A.; Gentile, A. (2018). Exploring Usability and Accessibility of Avatar-based Touchless Gestural Interfaces for Autistic People. In Proceedings of the 7th ACMInternational Symposium on Pervasive Displays,Munich, Germany, 6–8 June 2018; pp. 1–2. https://doi.org/10.1145/3205873.3210705
Spallazzo, D. (2016). Strategies to engage visitors through mobile technologies: considerations from the experimental action. In *Designing Multivocal Museums: Intercultural Practices at Museo Diocesano, Milano.* (pp. 116-126). Politecnico di Milano, Department of Design.
Spence, C. (2020). Scenting the anosmic cube: On the use of ambient scent in the context of the art gallery or museum. i-Perception, 11 (6). https://doi.org/10.1177/2041669520966628
Taormina, F., Baraldi, S. B. (2022). Museums and digital technology: a literature review on organizational issues, European Planning Studies, 30:9, 1676-1694, https://doi.org/10.1080/09654313.2021.2023110
Tzima, S., Styliaras, G., & Bassounas, A. (2021). Revealing Hidden Local Cultural Heritage through a Serious Escape Game in Outdoor Settings. Information, 12(1), Article 1. https://doi.org/10.3390/info12010010
UNESCO (2009) *Framework for Cultural Statistic,* http://uis.unesco.org/en/glossary-term/cultural-services.

UNESCO. (2022). *Climate Change and World Heritage*. https://whc.unesco.org/en/climatechange/
Valeonti, F., Bikakis, A., Terras, M., Speed, C., Hudson-Smith, A., & Chalkias, K. (2021). Crypto Collectibles, Museum Funding and OpenGLAM: Challenges, Opportunities and the Potential of Non-Fungible Tokens (NFTs). Applied Sciences, 11(21), 9931. https://doi.org/10.3390/app11219931
Vaz, R., Fernandes, P.O. Veiga, A.C.R. (2018). Designing an interactive exhibitor for assisting blind and visually impaired visitors in tactile exploration of original museum pieces. Procedia Comput. Sci., 138, 561–570. https://doi.org/10.1016/j.procs.2018.10.076
Verhulst, I., Woods, A., Whittaker, L., Bennett, J., & Dalton, P. (2021). Do VR and AR versions of an immersive cultural experience engender different user experiences? Computers in Human Behavior, 125, 106951. https://doi.org/10.1016/j.chb.2021.106951
Vi, C. T., Ablart, D., Gatti, E., Velasco, C., & Obrist, M. (2017). Not just seeing, but also feeling art: Mid-air haptic experiences integrated in a multisensory art exhibition. International Journal of Human-Computer Studies, 108, 1-14. https://doi.org/10.1016/j.ijhcs.2017.06.004
White, J. (ed) (2017). Museum as site for social action (MASS) toolkit. https://static1.squarespace.com/static/58fa685dff7c50f78be5f2b2/t/59dcdd27e5dd5b5a1b51d9d8/1507646780650/TOOLKIT_10_2017.pdf
Whitelaw, M. (2015). Generous Interfaces for Digital Cultural Collections. Digital Humanities Quarterly, 9(1), 1-16. http://www.digitalhumanities.org/dhq/vol/9/1/000205/000205.html
Windhager, F., Federico, P., Schreder, G., Glinka, K., Dörk, M., Miksch, S., Mayr, E. (2019). Visualization of Cultural Heritage Collection Data: State of the Art and Future Challenges. IEEE Transactions on Visualization and Computer Graphics. 25. 2311 - 2330. https://doi.org/10.1109/TVCG.2018.2830759.
Yeom, I., & Woo, W. (2021). Digital Twin as A Mixed Reality Platform for Art Exhibition Curation. 2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), 424–425. https://doi.org/10.1109/VRW52623.2021.00094

About the Authors:

Giuseppe Carmosino: architect, exhibition designer and PhD candidate in Design at Politecnico di Milano. His research work investigates the development of spaces and services on cruise ships, with a focus on the use of smart technologies and their contribution to passengers' information and entertainment.

Beatrice Gobbo: Currently Assistant Professor in the Centre for Interdisciplinary Methodologies at the University of Warwick, she received her PhD in Design from the Design Department of Politecnico di Milano, where she was a member of the DensityDesign Lab. Her work and academic interests are positioned at the intersection of information design computer science and social sciences, exploring Explainable Artificial Intelligence issues from a communication design perspective.

Martina Motta: PhD in Design, she is Research Fellow at the Department of Design (Politecnico di Milano). Her research activity in fashion and knitwear design mainly works on the convergence of traditional manual techniques with advanced industrial technologies and processes.

Eleonora Lupo: Designer, Ph.D. in Disegno industriale e comunicazione multimediale, she is an Associate Professor at the Design Department of the Politecnico di Milano. Her main research interests are focused on Humanities and Culture Driven Innovation, Design for Cultural Heritage and Product and Processes Design Cultures.

Michele Mauri: Researcher at Politecnico di Milano's Design Department. He coordinates DensityDesign, a research group focused on communication design in

information and data visualization. He co-created_RAWGraphs, an open-source visualization tool

Marina Parente: Architect, Ph.D., Associate professor at the Design Department of the Politecnico di Milano, she coordinates the research network "D4T - Design for Territories". Her research focuses on strategic design for local development and enhancing territorial resources and cultural heritage.

Federica Rubino: Ph.D. candidate with a scholarship on design-driven approach and performance management for digital innovation in museums, between Design and Management Engineering Departments at the Politecnico di Milano. Her academic and professional interests cover management of museums and cultural institutions, digital transformation of museums, and participatory practices in heritage management.

Elena Spadoni: Interaction Designer and a PhD candidate in Design at Politecnico di Milano. Her research mainly concerns the design of a new collaborative process to facilitate the integration of immersive technologies in museum exhibition visits.

Davide Spallazzo: Associate professor at the Department of Design of Politecnico di Milano. His teaching and research activity lies in Interaction Design and Human-Computer Interaction, focusing on technological solutions in the Cultural Heritage field.

Aknowledgment: The authors wish to thank the entire group of researchers who took part since November 2021 in the development of the present article, in particular the leading team of the Design Think Tank, Design Department, Politecnico di Milano: professors Anna Barbara and Venere Ferraro. Indirect assistance has also been provided by other researchers, named in the following Contributorship section.