

The Hybrid Museum

Digital transformation¹ made easy



Eye4Wonder
Enhance digital twins



360TIKS
Generate digital twins

¹ We follow the terminology on digital transformation as proposed by Europeana:
“[Digital transformation is] both the process and the result of using digital technology to transform how an organization operates and delivers value. It helps an organization to thrive, fulfil its mission and meet the needs of its stakeholders. It enables cultural heritage institutions to contribute to the transformation of a sector powered by digital and a Europe powered by culture.”

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Preface

360tiks and Eye4Wonder combine their advanced services to assist you on the road to enhance your **digital footprint**. By generating and enhancing digital twins, museums can easily transition to a hybrid model and achieve digital transformation with no technical expertise required.

Our DIY culture allows museums to independently control, create, and cultivate digital activities, offering real-time and on-demand experiences. With a robust suite of gamification tools and many features for orchestrating live meetings within the digital twin, museums can engage their audiences in exciting and meaningful ways—at an affordable subscription fee. For those seeking a more tailored experience, our expert team is available to create exceptional, gamified experiences for children and adults.

The hybrid museum does not replace the visit to the physical museum; it enhances, supplements, and enriches it. Think of the hybrid museum as a physical and digital flow. Imagine a kid participating in a guided tour to prepare them for the coming museum field trip or a senior citizen who visited the physical museum and is now attending a live meeting with the artist and the curator at the digital twin to gain more insights, ask questions and participate in a shared experience that enriches the physical encounter they had earlier.

This flow—from the physical to the digital and back—enables visitors of all ages to interact with the museum content in a personal, flexible way, whether before or after their physical visit, in live encountered and in on-demand sessions, bridging the gap between the physical and digital worlds.

As a first step toward a hybrid museum, Eye4Wonder provides a numeric guide. An easy-to-implement service enables visitors to use their mobiles, click on numbers, and get situated audio and video throughout the exhibition.

360tiks and Eye4Wonder suit, at an affordable subscription fee, propels you quickly and efficiently into the 21st century, **addressing the challenges posed by a digitally savvy audience that expects seamless brand interactions across all platforms.**

Digital Transformation

How Eye4Wonder and 360tiks help museums achieve digital transformation

Integrating the services of 360tiks and Eye4Wonder offers museums an efficient and cost-effective pathway into the 21st century, addressing the challenges posed by a digitally savvy audience that expects seamless brand interactions across all platforms. Digital transformation in museums is essential to meet evolving visitor expectations and to remain relevant in today's digital landscape. A study published in Heritage² highlights that while digital technologies have become integral, museums face organizational and technical challenges in their digital transformation efforts.

By leveraging 360tiks' digital twin creation and Eye4Wonder's enhancement tools, museums can develop a robust digital presence without the need for extensive technical expertise. This approach empowers institutions to independently manage and cultivate their digital activities, offering both real time and on demand experiences. Additionally, the incorporation of gamification features and live meeting capabilities within the digital twin fosters interactive and engaging experiences for visitors. This comprehensive solution enables museums to effectively bridge the gap between physical and digital realms, providing a cohesive and immersive experience for their audiences.

² See Appendix A

Eye4Wonder | 360tiks Service Suit - Benefits

The combined **Eye4Wonder** and **360tiks** service suite effectively addresses the challenges outlined in the 'Museums and the Post-Digital: Revisiting Challenges in the Digital Transformation of Museums³' research by providing museums with a comprehensive, **affordable solution** that enhances digital capabilities without the need for programming or technical expertise. The Eye4Wonder | 360tiks service suite empowers museum personnel to produce **ongoing, interactive meetings** and **digital tours**—not one-time solutions. This ensures that museums are not trapped in a cycle of obsolescence but can continuously iterate, improve their offerings, and engage/educate their audiences in dynamic, meaningful ways.

Meeting the Digital Transformation Challenges

The suite's **user-friendly tools** alleviate the complexity and **financial burden** of producing high-end hybrid experiences. By enabling museum staff to independently create **digital twins, interactive tours**, and **live meetings** within the museum's digital space, Eye4Wonder and 360tiks equip them with tools to develop and maintain a **sustainable digital presence**. This approach allows museums to adapt and evolve their digital strategies over time without constantly relying on external technical resources. Using the Eye4Wonder | 360tiks service suite, museums can cultivate their digital thinking iteratively, integrating new digital approaches that enhance engagement and maintain relevance in the **post-digital era**.

Enhancing Ongoing Communication and Education

Unlike the research's traditional "one-time solutions" mentioned, Eye4Wonder's service suite ensures that the museum's **digital engagement** is ongoing and adaptable. Museum staff can **organize regular live meetings** with curators, educators, and artists in the **digital twin**, fostering **continuous interaction** with their audiences. Similarly, **interactive digital tours** can be updated and restructured to meet evolving educational needs and visitor interests, ensuring the museum's content remains fresh and relevant. This flexible, **iterative model** empowers museums to engage their audiences continuously without the risk of digital stagnation.

³ *Heritage* **2024**, 7(3), 1784-1800; doi.org/10.3390/heritage7030084 See Appendix A

Empowering Staff Without Technical Expertise

Eye4Wonder provides museum personnel with tools that require **no coding or technical knowledge**. The service suite enables staff to easily create and manage **personalized, gamified tours** and **live meetings**, allowing them to focus on **creative content** rather than complex technical tasks. This reduces the **financial burden** often associated with high-end digital transformations, making the process accessible for museums of all sizes and budgets. Museums can now enhance their **digital offerings** on their own, fostering **autonomy** and reducing reliance on external tech support.

By fostering **independence** and gradually reducing reliance on external tech support, museum personnel can gain full autonomy in managing their digital experiences. This transition can be achieved step-by-step through the **Custom Plan**, where the **Eye4Wonder team** collaborates with the museum to create the first set of experiences. Based on this hands-on demonstration of **best practices** and digital interaction-related **thought processes**, the museum team can develop their own way of building and managing their hybrid museum. This approach ensures that the museum team is equipped with the knowledge and tools to handle their digital content moving forward confidently.

Expanding Reach and Personalization

By leveraging these **accessible digital tools**, museums can break free from the **limitations of proximity, cognitive levels, language, and more**. The hybrid model allows museums to engage with audiences far beyond their physical location, enabling them to reach **global visitors** and audiences with diverse needs. The personalization capabilities built into Eye4Wonder's tools make adapting content for **varied cognitive levels**, languages, or even specific interests easy. This enables museums to create **tailored programs** that cater to different audience segments, enhancing the inclusivity and reach of their offerings.

A New Social Rapport with Visitors

The Eye4Wonder | 360tiks service suite fosters a new **social rapport** between the museum and visitors. By extending the visitor experience beyond the physical space and creating **interactive, engaging digital environments**, museums can build lasting relationships with their audiences. This shift enhances the **hybrid museum experience**, encouraging ongoing dialogue and fostering a sense of community between the museum and its global visitors. As a result, museums can transform their digital presence into a unique cultural offering that resonates with a wide array of audiences and reflects the museum's evolving role in the **digital age**.

Eye4Wonder | 360tiks Service Suit - Components

In today's fast-evolving digital landscape, museums face the challenge of engaging a digitally savvy audience that expects immersive and interactive experiences both physically and virtually. Eye4Wonder and 360tiks provide a comprehensive solution that empowers museums to undergo **digital transformation** without the need for specialized technical or coding skills. This service suite is built around **four key components**: Documentation, Education, Live Meetings, and Numeric Guides. These tools work together seamlessly, creating a hybrid museum model that enhances both physical and digital interactions. By providing easy-to-use tools with a modest subscription fee, museums can foster deeper engagement with their visitors, expand their digital footprint, and create a more inclusive, accessible experience—all while maintaining control over their digital presence. This solution is designed to empower museums, regardless of their size or technological expertise, to effectively adapt to the demands of the 21st century.

Documentation - 360tiks

360tiks offers cutting-edge documentation services by creating **digital twins** of museum exhibits and heritage sites. This allows institutions to digitally preserve their collections and exhibitions and make them accessible to a wider audience. With high-quality scanning technology, 360tiks captures every detail of the physical spaces, transforming them into immersive digital environments. These digital twins can be accessed remotely, providing a platform for virtual tours and ensuring that exhibitions remain available even after they have physically closed. The documentation service provides museums with a dynamic and lasting record of their exhibits, preserving cultural heritage for future generations while expanding the reach of their collections.

Education - Eye4Wonder

Eye4Wonder elevates the educational experience within museums by providing powerful tools for **creating interactive tours and engaging content**. The **Tour Maker** and **Tour Viewer** enable museums to design educational pathways, incorporating media, gamification, and storytelling techniques. These features help guide visitors through exhibits in a way that promotes learning and deeper engagement. Museums can create tailored experiences for various audiences, from school children to adult learners, ensuring that the educational value of the exhibits is maximized. The integration of edutainment tools within the digital twin environment makes museum visits more interactive, enhancing both virtual and in-person learning experiences.

Live Meetings - Eye4Wonder

Eye4Wonder takes the concept of **live meetings** to a new level by integrating them into the **digital twin** experience. Museums can host **real-time interactions** with curators, artists, or educators within the virtual space, allowing remote visitors to engage directly with the content and experts. These live meetings can involve up to 20 participants, making them ideal for both intimate sessions and group sessions. The integration of gamification and interactive tools within these live sessions ensures that participants remain engaged, with activities such as live Q&As, tasks, and collaborative discussions, gamified game play and guided open ended quests. This feature enhances the hybrid museum model, allowing visitors to experience live, personalized encounters regardless of their location.

Numeric Guide - Eye4Wonder

The **Numeric Guide** feature from Eye4Wonder offers an innovative way to enhance the **museum experience** through a **mobile guide**. Download the mobile guide by scanning a QR code, and that would be the last QR code you will need. This tool allows museums to create personalized, **self-guided tours** without requiring technical knowledge. Visitors can simply tap on numbers, as you approach artifacts exhibiting numbers and you will see video or audio content on your mobile, enhancing their visit and enabling a deeper understanding of the exhibits. The mobile guide is a lean and affordable option for museums looking to offer a flexible and user-friendly experience, giving visitors the autonomy to explore at their own pace while still receiving a rich, informative tour.

Eye4Wonder | 360tiks Service Suit – Features

On demand Tour

The **Tour Maker** in Eye4Wonder offers a powerful suite of tools to create interactive, dynamic digital tours within the museum's digital twin. Here's an overview of its capabilities:

Content and Media Actions:

The Tour Maker allows you to add **content actions** at each step in the tour. These actions can include **text** and various media files such as **sound, video, PDFs, and images**. You can annotate media files and associate them with specific steps in the tour, providing a richer, more informative experience.

Progress and Navigation:

Visitors can seamlessly move through the digital tour with features like **Next Place**, which automatically jumps them to the next point in the timeline, or **Hold**, which allows the visitor to control when to proceed by waiting for them to reach a designated point in the digital twin. For self-paced exploration, the **Hold** action lets the visitor explore and continue when ready, while the **Next Place** action keeps the tour moving forward.

Interactive Actions:

The Tour Maker supports interactive actions such as **Quizzes** (e.g., riddles with multiple-choice answers), **Linking** to external content that opens in a separate window, and the **Look Action** that directs visitors to focus on a specific area in the digital twin (e.g., turning around or zooming in). These features enhance engagement and participation.

Match and Puzzle Actions:

Visitors can interact with the digital twin through **outline drawing**, where certain elements in the space are outlined. The visitor must find the matching objects in the environment. Additionally, the **Capture and Match** feature allows visitors to match visual elements to existing artifacts within the digital space and capture an image to generate a jigsaw puzzle based on images captured from the digital twin. These activities make the tour more engaging by involving the visitor directly in the exploration process.

Text and Multi-Text Capabilities:

The Tour Maker allows for rich, multi-line text, ensuring ample space for detailed descriptions or narratives at each step of the tour. The flexibility in text length ensures that you can provide in-depth context where necessary.

Customizable Timing:

With the **Wait** action, you can introduce delays between steps in the tour to control the pace. You can also create a timed experience for the visitor, adjusting how quickly they move from one section to the next, and offering a more tailored experience.

By using these capabilities, the **Tour Maker** empowers museum staff to craft detailed, customized, and engaging digital tours that are both interactive and educational. This allows museums to offer enriching on-demand experiences to visitors, best suited to educational use cases for kids, students, and informal learners (See the benefit of gamification in digital interaction to maintain attention, support engagement, and clarify content).

Live Meetings

The **Meeting** feature in Eye4Wonder allows facilitators to create dynamic, interactive, and engaging live meetings within the digital twin. Here's an overview of its capabilities:

Pre-set Content and Activities:

Before a meeting begins, a guide can pre-define **content and activities** that will be available throughout the session. This includes **text** (one line or multi-line), as well as multimedia elements such as **sound, video, PDFs, images**, and **titles**. These elements can be summoned at will and incorporated into the meeting flow, ensuring flexibility and a rich and engaging experience.

Individual and Group Assignments:

During the meeting, the **guide** can assign **tasks** to individual participants or the entire group simultaneously. This is particularly useful for managing different levels of interaction and ensuring that everyone is involved. The guide can also ensure that private tasks are given to specific people without including those who are assigned group tasks, enhancing the personalized experience.

Interactive Actions:

A variety of **interactive actions** can be added to the meeting to keep participants engaged:

Quiz: To check understanding or add an interactive challenge.

Timer (Wait): Introduces time-based actions, either to manage the flow or to hold participants at a certain point.

Outline Draw: Allows the guide to outline certain elements in the digital twin, prompting participants to find or focus on them.

Pearl and Match Actions:

The **Pearl** action hides a visual pearl within the digital twin, allowing participants to **find it** during the meeting. Similarly, the **Match** action can be used to create interactive activities like **puzzles** or matching exercises. This could include tasks where participants need to match images or objects within the digital environment, promoting interaction and problem-solving.

Control Visitor Movement:

The **Stuck** action is useful for guiding visitors by setting time limits that prevent them from moving ahead until the designated time or task is completed. This feature ensures that visitors stay engaged and focused on the current part of the meeting before progressing.

Media Integration:

Meetings can be enriched with **media** elements, including **sound, video, images, PDFs,** and **multi-line text**. This enhances the immersive experience, making the meeting more engaging and informative for participants.

By integrating these features, the **Meeting** tool provides a comprehensive platform for conducting live, interactive sessions in the digital twin, whether for guided tours, Q&A sessions, or collaborative activities. This allows guides to offer a **personalized, dynamic experience**, whether they're addressing an individual participant or engaging the entire group in an interactive discussion.

Eye4Wonders' Numeric Guide

Eye4Wonder provides a numeric guide. An easy-to-implement service enables visitors to use their mobiles, click on numbers, and get situated audio and video throughout the exhibition. A QR code is available at the entrance to download the app; apart from that, there is no need to scan a QR code to elicit a response repeatedly. Here's an overview of its capabilities:

Pre-set Content and Activities:

The museum personnel use the Eye4Wonder management screen to launch a numeric guide. They define **the content** (Audio/video) for each part of the tour, ensuring visitors have a rich multimedia experience as they explore the physical museum.

Visitor-Controlled Experience:

The **Numeric Guide** empowers visitors to navigate their own path through the physical museum, offering **flexibility** to explore at their own pace. Visitors can scan a **QR code** to access the digital content, allowing for a **self-guided tour** that fits their preferences and schedule.

Personalization:

One can create several guide variations to be **tailored to specific visitor needs** based on cognitive level, language preferences, or interests. This makes it adaptable for a wide range of audiences, from school groups to seniors, offering a more **personalized and inclusive experience**.

Seamless Transition:

As visitors progress through the physical museum, the **Numeric Guide** ensures a smooth flow, guiding them from one section to the next without the need for constant supervision. This self-paced, **on-demand experience** ensures that visitors can explore and engage with the content at their own convenience while still receiving rich, informative content.

Easy Setup and Management:

Museum staff can create, update, and manage the **Numeric Guide** without technical expertise. The platform allows for easy customization of content and activities, empowering museums to maintain control over their **digital content** and **visitor experience** without relying on outside tech support.

Utilizing these features, the **Numeric Guide** becomes a flexible tool that can be tailored to as many audiences and exhibitions as needed.

360tiks' Documentation

360tiks offers cutting-edge documentation services by creating **digital twins** of museum exhibits and heritage sites. This allows institutions to digitally preserve their collections and exhibitions and make them accessible to a wider audience. With high-quality scanning technology, 360tiks captures every detail of the physical spaces, transforming them into immersive digital environments. These digital twins can be accessed remotely, providing a platform for virtual tours and ensuring that exhibitions remain available even after they have physically closed. The documentation service provides museums with a dynamic and lasting record of their exhibits, preserving cultural heritage for future generations while expanding the reach of their collections.

360tiks offers comprehensive documentation services for museums and heritage sites, both indoor and outdoor, utilizing advanced panoramic capturing technology to create immersive 3D digital tours. Apart from the actual tour, there are supplement digital artifacts that are generated from the 3d digital tour, such as high-definition images and detailed floor plans, 3d cloud point files, etc.

The museum can use these artifacts to enhance social campaigns.

Online visitors can experience exhibitions as if they were physically present.

Additionally, 360tiks facilitates the publication of these virtual tours to platforms like Google Street View, expanding the museum's online presence and accessibility.

The integration of virtual reality (VR) mode allows for an even more immersive experience, enabling users to explore spaces in a fully interactive environment. This comprehensive approach ensures that exhibitions remain accessible to a global audience, preserving cultural heritage and extending the museum's reach beyond physical boundaries.

Sources

Subscription Plans

Feature	Plan A - Numeric Guide	Plan B - Basic	Plan C - Pro	Custom Plan
Numeric Guide Maker	Yes	No	No	No
QR Generator	Yes	No	No	No
Tour Maker	No	Yes	Yes	Yes
Tour Viewer	No	Yes	Yes	Yes
Meeting Maker	No	Yes	Yes	Yes
Meeting Viewer	No	Yes	Yes	Yes
Live Meetings	No	Up to 3	Unlimited	Varies
Independent Tours	No	Yes	Yes	Yes
Maximum Open Tours	Up to 3	Up to 3	Up to 12	Varies
Pay-Per-Meeting	No	Yes (160 NIS)	Yes (160 NIS)	Yes (Custom)
Custom Tour/Meeting Creation	No	No	No	Yes
Discount for Adding Numeric Guide	No	No	No	50% off

Add-ons and Discounts:

Numeric Guide Discount: If you already have Plan B or C, and you wish to add a Numeric Guide, you will receive a 50% discount on the Numeric Guide Plan.

Appendix A

Essay

Museums and the Post-Digital: Revisiting Challenges in the Digital Transformation of Museums

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Abstract: This paper considers the digital transformation of museums and, particularly, the challenges museum professionals face today in the implementation of digital practices. The exploration of the challenges that museum professionals need to address, and the values associated with the “digital” are critical in the context of current and rapid sociocultural and technological changes. This paper reviews a diverse typology of resources—including project reports and deliverables, qualitative and quantitative surveys, academic articles, edited volumes, and chapters—relevant to the implementation of digital practices in the “backstage of museums.” This essay will show that, although digital technologies have acquired a normative presence, organisational and technical challenges in the “backstage” of museums pose systemic problems in their digital transformation. These are systemic problems related to skills and knowledge, and human and financial resource deficits, which result in museum professionals exerting constant effort to keep up with the rapid changes in digital technologies with limited resources at hand and the risks of technological obsolescence and abandonment always present. Situated within the emerging literature advocating for a holistic, ethical, and sustainable digital transformation of museums, this paper draws attention to the implications of the digitalisation of museums in the transition to a responsible and sustainable digital future in a European context. It argues that a relational understanding of sustainability and ethics can be a pivotal first step towards the formation of a digitally purposeful museum in the post-digital era.

Keywords: cultural heritage; museums; digital transformation; museum professionals



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1. Introduction

In the context of the ReInHerit project (Id No. 101004545), funded by the European Commission’s Horizon 2020 research and innovation programme, a series of focus group interviews with 38 professionals from 10 European countries was conducted in March 2022 to investigate digital transformation in small- and medium-sized museums in Europe [1]. The aim was to explore the barriers, opportunities, and motivations for adopting digital technologies in museums and the value that they bring [1]. The participants were professionals with different types of expertise (ICT, curation, museum education, public officers, academic researchers) working in or collaborating with different types of museums. During the focus group interviews, the participants discussed at great length the challenges they faced during the implementation of digital technologies in museums they either worked in as permanent or contractual personnel or as external collaborators [1]. However, the results of the ReInHerit focus group interviews represent the perceptions of a small cross-section of professionals in Europe, and their experiences are particular to their educational and social contexts. Prompted by this, the aim of this paper is to critically reflect on the digital transformation of museums by reviewing a diverse typology of resources. In doing so, it draws attention to the challenges museum professionals face during the implementation of digital activities and to their implications in the transition to a responsible and sustainable digital future in a European context.

The term “digital transformation” is used in different ways by different sectors [2], and for this reason, this paper follows the terminology on digital transformation as proposed by Europeana. The independent charity Culture24 [3] was commissioned by Europeana as part of its capacity-building project to draft the “Digital Transformation in the Time of COVID-19” workshop. Building on these findings, Europeana proposes a definition for digital transformation, the summary of which is:

“[Digital transformation is] both the process and the result of using digital technology to transform how an organization operates and delivers value. It helps an organization to thrive, fulfil its mission and meet the needs of its stakeholders. It enables cultural heritage institutions to contribute to the transformation of a sector powered by digital and a Europe powered by culture.” [4]

This is seen as the contemporary condition of museums, as museums have entered their post-digital era where digital technologies have acquired a “normative presence” [5] (p. 2): (a) in the institution’s operations, such as collection management, conservation, communication with audiences through social media and websites, educational activities, exhibitions, and ticketing; (b) in the ways museum professionals understand their relationships with their audiences; and (c) in how visitors experience cultural heritage [6–11]. It is important to note that the use and typology of technology vary greatly between institutions due to their specific organisational, infrastructural, and policy contexts that condition their digital capacity [12–14]. This points to Francesca Taormina and Sara Bonini Baraldi’s [15] proposal that digital transformation, or the digitalisation, of museums requires a multidimensional analytical approach that looks at museums from an operational, organisational, and strategic perspective. Similarly, Maria Shehade and Theopisti Stylianou Lambert [7] note that the perceptions and experiences of museum professionals with emerging technologies need to be explored in more depth to contribute to the current literature [16,17]. It is important, in other words, to look “behind the scenes” of museums [18] because they are working places for professionals to engage in “everyday organizational processes and administrative practices and inhabit the workplace with all its complexities and contradictions” [19] (p. 112). Drawing from this literature, this paper explores digital transformation in the current post-digital circumstance by looking at the “backstage” of museums with a specific focus on the challenges museum professionals need to address.

2. Materials and Methods: Reviewing the Challenges in the Digital Transformation of Museums

2.1. Museums and Digital Technologies: Providing a Context

This section gives a brief overview of digital technologies in museums with the aim of providing context for the main concern of this paper, which is the current challenges or barriers museum professionals face when implementing digital technologies. The new museum definition reflects the paradigm shift from collection-centric to user-centric that has been taking place in the past decades [20–22]. The new definition was approved by the Extraordinary General Assembly of the International Council of Museums on 24 August 2022, after an open and long process of consultation about the Standing Committee of the Museum Definition with the National Committees, International Committees, Regional Alliances, and Affiliate Organizations. The definition states that:

“A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing.” [23]

The new museum definition illustrates how museum work now strives to follow an inclusive and democratic human-centred approach to sustain a range of movable and immovable assets, as well as being open to different voices of interpretation and providing visitors with meaningful experiences through active engagement with the collections [16,22,24]. Digital technologies are used in museums to enhance this new role by making them more accessible, engaging, fun, and attractive, and by creating a unique and memorable experience. This value of technologies in museums is distinctive of our time, in which museums have shifted from “being about something to being about someone” [25]. Technologies entered the world of museums in the second half of the twentieth century, with the first conference on museums and computers taking place in 1968 at the Metropolitan Museum of Art in New York [26]. In this early stage, technologies were used for recording, cataloguing, and researching collections; by the end of the century, their use was expanded to the digitization of museum collections (usually through funded projects) [9]. At the turn of the 21st century, “new technologies” were introduced in exhibitions to increase interaction with visitors [27].

With the advent of Web 2.0 and the ensuing sociocultural transformations, consumers have become active participants in the production of cultural value and meaning through digital infrastructure [28]. Felix Stalder [29] refers to this as the “digital condition,” where referentiality, communality, and underlying algorithms are its characteristic forms. Referentiality denotes how users can “inscribe themselves into cultural processes and constitute themselves as producers” [29] (p. 58); communality is “understood as shared social meaning” [29] (p. 58), where meaning-making processes take place in a larger communal framework; and algorithmicity refers to the facets of cultural processes that are mediated and transformed from “big data” to “small data” by algorithms before reaching human perception (such as Google’s search algorithm). There is a growing discussion in the literature on how museums are responding to this sociotechnical and cultural context brought by the “digital condition” and to the many functions—such as tool, platform, content, and format—of digitality [30–32]. Sejul Malde et al. [33] (pp. 23–24) propose a model consisting of four components or key meanings for defining the active relationship of an individual with the “digital” in the museum context, and these are: (a) how the digital is used either as software or hardware; (b) how the digital is managed as a process entailing vision, strategy, and protocols; (c) how the digital is understood in terms of motivation, behaviour, and impact; and (d) how we create with the digital in our contemporary circumstance. This model is not intended to be rigid but rather to help people think about the “digital condition” in their specific context. Along this line, Jenny Kidd et al. [34] have shown that the “digital” has brought a fundamental shift in how museums engage with their audiences and communities, not only in terms of formats and platforms but also in how the digital is considered a mindset characterised by collaboration, participation, and audience-centricity.

An important idea that conceptualises the active relationship between the digital and museums is that of the “distributed museum” [35–38]. Although the concept has various but complementary approaches, the “distributed museum” could be described as a “space inhabited by people and museum professionals engaging over time across platforms and in multiple locations, negotiating an emergent understanding of cultural heritage” [37] (p. 83). In accordance with Andrew Dewdney et al. [38] (p. 189), the concept of the “distributed museum” brings to the fore “the networked, relational, hybrid and performative dimensions of the museum.” The concept of the “post-digital museum” is another important notion that encapsulates the current circumstance (our post-digital moment) where the digital has acquired a normative function in societies and museums

and is no longer considered disruptive [5]. The post-digital museum has accepted (a) the normative presence of the digital in its operations and performance and (b) the audiences' changing roles. This acceptance has occurred despite the scale or extent to which a museum has adopted digital technologies due to constraints in financial and human resources [32].

Synchronicity and the invisibility of digital technologies are two important elements in the post-digital museum and the societies in which they operate. The contemporary present is characterised by a “coming together of different but equally ‘present’ temporalities or ‘times’, a temporal unity in disjunction” [39] (p. 17), where digital technologies have been infused into material and non-material things and spaces that render them less visible to users [32]. This invisibility is supported by data, a global labour force, and secure servers connected to financial systems, whereas on the front-end, digital technologies operate as naturalised, socialised, and mobile [38]. Alexandra Bounia argues that this signifies an ontological turn where technology has become an inherent part of all aspects of our lives and the societies in which museums operate [32]. For the post-digital museum, this ontological turn means that we have moved from the era of the digital revolution to a change in what museums are and their practices [40]. This is seen in the scholarly and critical reflection on digital technologies in museums (looking at how, why, and where they are used, by whom, and what they enable), which is considered a key characteristic of the post-digital museum.

The diverse use of different types of digital technologies (VR/AR, 3D reconstructions, interactives, audio or multimedia guides, social media, etc.) has been examined in relation to issues such as power, authenticity, and representation [8,27,31,41]. The advantages and disadvantages of using digital technologies in mediating museum collections to visitors have long been a subject of discussion as well; examples include the risk of Disneyfication, which means entertainment is more of a priority than the provision of factual education [42]; whether technological tools can potentially distract visitors or isolate them from their social surroundings during their visit in the museum and limit their interaction with other visitors [43]; and how the “generational divide” materialises into different expectations on the value of technology in museums [44]. However, the perceptions and experiences of museum professionals in adopting digital technologies are understudied, especially the challenges in the digital transformation of museums, which are noted but not explored in depth and, as such, require further exploration [7,45]. The next section reviews the digital turn that occurred during the COVID-19 pandemic to contextualise how it was materialised in museums—which are understood here, in the words of Manuel DeLanda, “as an assemblage of different specialist activities, knowledges, departments, roles, policies and physical sites” cited in [46] (p. 69)—and how it affected their digital transformation.

2.2. *The Digital Turn during and after the COVID-19 Pandemic*

When the COVID-19 outbreak occurred in March 2020 and the pandemic forced museums around the world to close, an unprecedented and dire situation took place. In accordance with the UNESCO report [47], over 86,000 museums closed in the first wave of the COVID-19 outbreak during spring 2020. This was followed by continuous restrictions that affected the regular operation of museums and rendered their physical collections, at their core, inaccessible to visitors. Museums turned to the digital in order to deal, simultaneously and quickly, with many issues, from the loss of a “qualified and valuable” workforce to the remote “safeguard and management” of buildings and collections to new ways to communicate with solely digital audiences and to respond to political protests (notably the Black Lives Matter movement) [9] (p. 63). The acceleration of the digital transformation in museums during the pandemic has been described as a digital “pivot” [34]. The digital “pivot” concerned strategies and practices because it was a period where museums “as institutions negotiated the sudden centrality of their online presence” and their relevance to their local communities [34] (p. 3).

Museums responded quickly to the dire situation brought by the pandemic by using different digital media and formats (such as websites and social media)—and not

groundbreaking technologies—to deliver their services and reach their audiences [48–54]. Beyond artificial intelligence, machine learning, and big data, digital transformation is connected to social change brought, largely, by social media, whereby the creation and consumption of meaning have become more open and blurred. As noted in the previous section, in museums, this has been translated into a change in the design and delivery of museum work by using audience-centred approaches and narrative (see, for example, the terms user experience, engagement, and co-creation) that became more evident during the pandemic [52,54]. Chiara Zuanni [55] developed a crowd-sourced digital map of museum activities during the pandemic that shows how museums drew on their existing resources (digitised collections) and on the new digital content they created. The new digital content—in the form of virtual tours, online exhibitions and educational activities, podcasts and quizzes, and social media interactions—became the core activities of museums [34,54]. Through the creation of this new digital content, museums also experimented with “hybrid” approaches by blending digital and physical experiences of their collections, events, and tours in the form of downloadable activities, calling for audiences to be creative at home and on behind-the-scenes tours [54]. Areti Galani and Jenny Kidd [56] (p. 300) describe this as “the production of digitally-mediated material encounters” and can be seen as part of the re-evaluation of museums’ relevance to local communities during the pandemic.

It is important to note that many issues arose due to the digital “pivot” of museums, including the question of the monetization of digital assets, communication between professionals during their remote work, the provision of digital access, and the creation of content that would stand out for its quality among so many other digital offerings [34,48]. Museums with prior digital infrastructure and strategy were in a more advantageous position to deal with the effects of the pandemic than less digitally mature museums. This brought to the fore persisting problems in the digital transformation of museums, including the “digital divide” in terms of inequality and access to digital infrastructure among visitors and museums alike, differences in revenue streams and in digital capacity, as well as the need for museums to adapt to the new paradigm of digital-only visitors. As Ross Parry and Vince Djiekan [57] (p.16) argue, this was the moment that showed “how critical the integration of “digital” is to the future of the museum” “. This integration requires fundamental changes in museums in terms of forms, conventions, practices, and communication because “the digital” cannot be considered an add-on tool to museum practices in today’s societies [32].

The first step towards this fundamental change is to have a more granulated and nuanced understanding of digital transformation in the backstage of museums and how museum professionals respond to it. To conduct a multidimensional examination of the challenges, museums are considered in this paper as “peopled organizations” consisting of norms, behaviours, routines, activities, regulations, tensions, materials, aspirations, and values [19] (p. 116). Following Areti Damala et al. [8] (p. 3), this paper uses the terms “digital technology” and “museum technology” as umbrella terms to cover the vast array of digital technologies used in museums today (VR/AR, online ticketing systems, content management systems, digital audio guides, 3D reconstructions, museum websites, digital exhibitions, etc.). To explore the challenges in the digitalisation of museums from the perspective of museum professionals, the next section reviews various types of resources, including project reports and deliverables, qualitative and quantitative surveys, academic articles, edited volumes, and chapters.

3. Results: Exploring Challenges in the “Backstage” of Digital Transformation in Museums

During the pandemic, ICOM and the Network of European Museums Organisations (hereafter NEMO) conducted longitudinal studies to measure the impact of COVID-19 on museums and their digital practices on a European and global scale. These surveys demonstrate that there are discrepancies between museums in terms of human and fi-

nancial resources available for the implementation of digital activities. ICOM conducted three surveys in the period between 2020 and 2021 looking at the impact of COVID-19 in museums. The ICOM 3rd Report [58] analyses data from 840 responses from different sizes of museums across five continents (the survey was open in spring 2021) and shows that 61% of museums had staff working on digital projects but not on a full-time basis; 17.1% declared that they did not have any personnel on digital projects; and 21.9% responded that full-time staff was employed. The NEMO follow-up survey [13] received responses from 600 museums from 48 countries between 30 October and 29 November 2020, with the majority coming from Europe. Over 8 in 10 museums suggested that they require additional support with digital tools and transition. Of those museums, over 40% required assistance with building a digital strategy, followed by the need for new digital infrastructure (23.2%) and staff training (18.7%) [13] (p.5). These surveys show that the “digital turn,” which occurred during the pandemic, is more complicated since museums with already established digital collections, practices, and strategies were quicker to adapt to the new situation than museums that had to rely on outsourcing their digital activities [9]. In the ICOM 3rd Report, it is noted that “the COVID-19 crisis has changed museums’ perception of the digital world forever, highlighting existing issues and accelerating changes that were already in progress” [43] (p. 17). The rest of this section will look into these existing issues by exploring the perceptions of museum professionals through a review of relevant studies.

Ana Carvahlo and Alexandre Matos [59] conducted 12 in-depth interviews and one focus group interview (12 participants) with museum professionals in Portugal in the context of the Museum Sector Alliance (2016–2019), an Erasmus Plus Program (Sector Skills Alliance) whose aim was to support ongoing professional development in museums in Greece, Italy, and Portugal [60]. They also conducted additional interviews with academics and professionals from external companies to further consolidate their results. In their analysis, Carvalho and Matos [59] identified the following challenges: complex maintenance of technological equipment and tools, a lack of a long-term strategy for replacing devices, and the fact that the adoption of digital technologies occurs in an “unstructured and fragmented way” [59] (p. 42). Developing digital applications is considered by this study’s interviewees as an add-on to museum work that has low rates of feasibility due to low budgets, small and multi-tasking teams, and low digital and communication maturity. In the same year, another study was published by Kati Price and Dafydd James [61], who conducted a survey in GLAM organisations with 56 respondents (64% of the responses were from museums), most of them located in the UK and North America, with the remainder being in Australia and Europe, and one in Brazil. These participants highlighted the underinvestment in digital skills, most notably in data analysis and technical leadership.

Paola De Bernandi et al. [62] conducted in-depth interviews with professionals working in 11 museums in Turin, Italy, to examine the role digitalisation plays in museums now and what role it will play in the future. Most of the museum professionals (9 out of 11) at the time of the interviews were still adopting an “unstructured approach” to the use of digital technologies [62] (p. 321), and only 6 out of the 11 museum professionals considered a digital strategy important and were willing to integrate it within the organisation [62] (p. 321). The main challenges identified by participants are systemic financial deficits, institutional pressures, and the lack of coordination between departments. Because the staff has different types of expertise (curation, marketing, and IT), there is difficulty in opening a dialogue between them. Based on their analysis, De Bernandi et al. [62] note old mindsets and cultural paradigms as key challenges in the digitalisation of museums.

Luna Leoni and Mateo Cristofaro [16] conducted a survey that was administered to the directors and curators of 194 Italian small museums. The purpose of this research was to analyse the “extent to which new technologies are adopted by SMs as well as what favours or is an obstacle to their adoption” [16] (p. 5). The most cited challenges are “technology maintenance” (costs associated with the technologies’ preservation) and “financial resources” (availability of internal/self-generated funds) (10% of the responses for each challenge); availability of personnel with technological skills (8% of the responses);

costs associated with technology adoption and/or the existence of hardware and software infrastructures (5% of the responses); and introduction of new technologies created to replace an older version (technological obsolescence) (4% of the responses). This study identified an important paradox: although museums adopted digital technologies based on various trends, these were not received well by visitors, and as such, the digital technologies had to be removed. The participants recognise the beneficial role of technology, but they are also “frightened by the hidden features of the technological element per se” [16] (p. 13). For the researchers in this study, the development of skills through training will provide professionals with the necessary knowledge to address these challenges.

Maria Shehade and Theopisti Stylianou Lambert [7] interviewed 16 museum professionals from 15 different museums in the US, Australia, Italy, the UK, the Netherlands, and Finland on the integration of virtual reality (hereafter VR). The barriers that have been identified relate to the lack of personnel and the necessary funds to hire more personnel and provide training; the need for VR-dedicated teams; and the costs and technical aspects of VR technologies. Specifically, due to the lack of visitors’ familiarity with VR technologies, extra personnel are required at the VR stations, and many museum professionals do not have the expertise for developing, handling, and troubleshooting VR projects. The issue of cost includes the initial equipment required, the extra staffing needs for developing and handling the VR, and the costs of repair and maintenance. This results in VR technologies being used mostly on a temporary basis, usually in exhibitions. At the same time, the authors note that, due to the rapid advancement of VR and other emerging technologies, dedicated departments or labs have started to be formed in some museums.

Paul Marty and Vivian Buchanan [17] present results from an online survey with 34 complete responses, conducted in October 2020, designed to explore the role of museum technology professionals in the US during times of crisis. One specific question they pose is relevant here: what are the most significant factors that contribute to the museum technology sector being negatively affected by financial struggles in times of crisis such as COVID-19? The most common responses were: 21.4% responded that there is a general misunderstanding about the time and effort museum projects need; 15.4% responded that museum technology work is undervalued compared to other museum sectors; and 12% responded that the behind-the-scenes work of museum technology workers is invisible. The study shows that some museums still perceive museum technology professionals a) as not essential to their operation (10.2%) and b) as expensive, which provides little return on investment (7.7%). The authors of the study highlight the importance of developing skills for advocating the value of museum technology, as the role of digital technologies in museums is often not understood.

Finally, in the context of the European-funded project ReInHerit (ID No. 101004545), five focus group interviews took place (online) in March 2022, with 38 heritage professionals participating from 10 European countries (Austria, Croatia, Cyprus, Finland, Greece, Italy, Spain, Sweden, Switzerland, and the Netherlands) [1]. The aim of the focus group interviews, part of a wider primary and secondary research project, was to explore the conditions of adopting and leveraging digital technologies for informing the development of the digital applications that the ReInHerit project would develop (<https://reinherit-hub.eu/> accessed on 4 March 2024). The professionals in these focus group interviews identified some key challenges in the implementation of digital projects, these being the high costs of developing and maintaining digital technologies; the rapid obsolescence of technologies; the ownership of digital objects; the lack of knowledge on the business requirements of using digital technologies; the problems in interoperability of data created from older technologies; and the knowledge gap between museum and ICT professionals, which creates obstacles in their in-between communication. It was noted during the interviews that museums “jump into the digital transformation activities” [1] (p. 37) without considering the life cycle of a digital application and the high costs for developing personalised content, training, supervision, and maintenance. The participants highlighted that digital applications are seen as “one-time solutions” [1] (p. 17) and are abandoned either because

their maintenance is expensive or because they have become obsolete. As a result, the participants commented that new digital applications need to be developed, a process that requires further use of resources for redeveloping and launching new apps from the ground up, thus hindering the process of digital innovation and its sustainability in the sector.

Although this brief review presents insights from museum professionals working in specific temporal and spatial contexts (see Table 1), when viewed together, a more nuanced image of barriers related to the digitalisation of museums is starting to emerge. Drawing from the literature [8,9,16,59,62], these barriers can be categorised into technical aspects (infrastructure, obsolescence, maintenance, cost) and organisational aspects (human and financial resources, vision) of digital activities. The technical aspects include the rapid obsolescence of digital formats; material artefacts, ownership, and data management; interoperability between digital formats and older technologies; and the high costs of developing and maintaining digital technologies and applications with personalised content. The organisational aspects include a lack of long-term vision, different levels of digital literacy between professionals that make communication difficult, and limited budgets available for hiring new staff and for digital projects. The organisational issues of limited budgets, being understaffed, and the need for digital literacy and digital skills are well-known and have been explored in specialised studies [60,63]. It has been argued that organisational culture can be an important inhibitor of digital development [48]. These challenges have been noted in the literature since the early 2000s, when museums considered “new technologies” as expensive and high-risk because of the technical issues of maintenance, costs, and training [15,48,49,64,65]. As also shown by the relevant literature and surveys [9,12–14], the challenges vary for different sizes of museums, as larger museums tend to have more resources to integrate digital applications. This review shows that, although digital technologies are no longer new and have acquired a normative presence in museums, the technical and organisational challenges persist, which makes them systemic problems. This means that the technical minefield, denoting the software and hardware components of digital technologies, is connected to the organisational aspects of human and financial resources, digital literacy, and values. For this reason, obsolescence, maintenance, and abandonment are key issues that will only become more pressing due to the rapid changes in the technical minefield of digital technologies. This raises a crucial question: what will the future of museums be?

Table 1. Comparative overview of challenges in the digital transformation of museums.

Study	Organizational and Technical Challenges
Carvalho and Matos 2018 [59]	<p>There is no long-term strategy for replacing technological devices. The adoption of digital technologies occurs in an “unstructured and fragmented way.” Digital applications are considered an add-on to the museum’s work. Low rates of feasibility due to the low budget, small, and multi-tasking teams. Low digital and communication maturity. Complex maintenance of technological equipment and tools.</p>
Price and James, 2018 [61]	Underinvestment in digital skills (data analysis and technical leadership).
De Bernandi et al., 2018 [62]	<p>Systemic financial deficit and institutional pressures. Lack of coordination between departments as staff have different types of expertise and difficulty communicating with each other. “Unstructured approach” in the use of digital technologies. Old mindsets and cultural paradigms are key challenges in the digitalisation of museums.</p>

Table 1. Cont.

Study	Organizational and Technical Challenges
ICOM 3rd Report, 2021 [58] and NEMO Follow-up Survey, 2021 [13]	Lack of human and financial resources for the implementation of digital activities. Support for museums is required for digitalisation (digital strategy, digitisation, and digital skills).
Shehade and Stylianou Lambert, 2020 [7]	Lack of personnel and the necessary funds to hire more personnel and provide training. Need for VR-dedicated teams. Lack of expertise for developing, handling, and troubleshooting VR projects. Costs and the technical aspects of VR technologies. VR is used for temporary exhibitions since the cost of maintaining VR on a permanent basis is prohibitive.
Leoni and Cristofaro, 2022 [16]	Lack of availability of personnel with technological skills. Costs associated with technology adoption (software and hardware) and maintenance. Introduction of new technologies created to replace an older version (technological obsolescence).
Marty and Buchanan, 2022 [17]	General misunderstanding about the time and effort museum projects need. Museum technology work is undervalued. Behind-the-scenes work of museum technology workers is invisible. Some museums consider museum technology professionals as not essential to the museum operation because it is expensive and provides little return on investment.
ReInHerit H2020, 2022 [1]	Lack of knowledge on the business requirements of using digital technologies. Knowledge gap between museum and ICT professionals, which creates obstacles in their communication. Digital technologies are seen as “one-time solutions” and are abandoned either because their maintenance is expensive or they have become obsolete. High costs of developing and maintaining digital technologies. Rapid obsolescence of technologies. Issue of ownership of the digital objects. Problems with the interoperability of data created by older technologies.

4. Discussion

The purpose of this paper has been to draw attention to the challenges of digital transformation in museums and to reflect on how they are taking place at the “backstage of museums” in the post-digital era in our current circumstances. In the post-digital era, digital technologies are no longer new or disruptive; they have formed different notions of time, space, and being, and they have become inseparable from social action [32]. Museums have accepted the normativity of digital technologies in their operation and performance, whether they have the capacity to adopt digital technologies or not, and to what extent. This review has shown that museum professionals seem to be exerting constant effort to keep up with the rapid changes in digital technologies, with limited resources at hand and the risks of obsolescence and abandonment always present. This creates a continuous cycle of developing new digital applications and technologies as “one-time solutions,” which points to the idea that digital technologies are thought of as supplementary to the traditional museum mission and, based on technocratic and financial criteria, are used to enhance the visitor experience of analogue collections in the specific bounded space of the museum [1,28]. However, digital technologies are not neutral tools in the service of museums; their technical minefield is interconnected with the values, subjects, culture, and concepts of museums. The term “digital” is often used to describe the new sociotechnical relationships—consisting of data, services, content, systems, technologies, and humans—where the internet is a “radical reconfiguration of how ‘the social’ is registered through the operations and functions of communication and

knowledge” [38] (p. 190). The “digital content” can then be seen at the same time as the “digital tool” that provides personalised content necessary to meet the different needs of different audiences [35]. Paraphrasing Parry [5] (p. 37), the acceptance of the normative presence of digital technologies on the one hand, by the majority of museums as shown by Marty and Buchanan’s study [17], and the systemic problems of human and financial deficits, along with the continuous cycle of obsolescence and abandonment on the other hand, signals the moment to reset our relationship with digital technologies in museums. This calls for a nuanced and critical understanding of the values embedded in museum technologies and their impact on societies.

Digital technologies are complex assemblages of data, of hardware, and of software (material and immaterial) depending on global internet traffic, which are ever-changing, creating new dynamics and relationships that require constant reflection and negotiation of traditional concepts such as authenticity, materiality, and power [10,27]. Fiona R. Cameron [66] (p.59) proposes to consider “the digitization more deeply as a new type of ecological composition within multiple, multi-scalar planetary computational structures” connected to consumption and, consequently, to carbon emissions. Digital technologies are distributed, have become “invisible,” and require the infrastructure and cloud servers that operate on the extraction of non-renewable materials, human labour, and data [28,66]. Pasqualina Sacco et al. [67] remind us that digital technologies have a life cycle, starting from the extraction of minerals to the manufacturing stages in factories in different countries and the development of the software, to their use, obsolescence, and the end of their life. In the life cycle of digital technologies, we need to consider the carbon footprint in relation to the increased electricity generation demand as well as issues of cybersecurity and the “digital divide” between those who have access to fast internet, information, and economic resources and those who do not benefit from these [68]. The challenges reviewed in this paper give insights as to how the digital transformation in museums is linked to technological waste, mining of raw minerals to make hardware, labour, and global supply chains through the continuous cycle of technological adoption and abandonment, thus creating new sociotechnical relationships that are in constant flux. In this line, Ed Rodley [37] (pp. 84–85) makes an interesting nod to the concept of “contact zones,” studied and applied to museums by James Clifford in the 1990s, by saying that “when museums are seen as contact zones, their organizing structure as a collection becomes an ongoing historical, political, and moral relationship.” It is important to consider this in relation to the digital transformation of museums and the ethical, political, and historical implications of the continuous cycle of adopting and abandoning technologies, as every local action has potential global effects.

Andrea Witcomb stresses the “constant danger of bringing in the new that it will soon become old” [40] (p. 486) and how it becomes higher in this era of climate crisis where “the future of humanity and the earth has become more precarious” [46] (p. 69). The continuous cycle of adopting and abandoning technologies and the increasing costs of interconnectivity, digital platforms, search engines, and data management systems bear important implications for the sustainability of museums and their (ethical, historical, and political) role in society, as envisaged in the new museum definition. Sustainability as a scholarly, governmental, and business field has grown exponentially since the 1972 UN conference on the environment [67]. There are many approaches to sustainability, but the most widely used is the one derived from the World Commission on Environment and Development and the Brundtland Report in 1987: “sustainable development seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future” [69]. Sustainability is considered to have the environment, economy, and society as its three pillars, with an increasing awareness of the role of culture in sustainable development [70]. This is the “triple-bottom-line” (3BL) sustainable management theory that sees economy, society, and environment as co-existing in a symbiotic relationship [71]. Sustainability has long been a subject of discussion in museums and cultural heritage [72–78], an example of which is the work on local communities and wellbeing [79]. In 2018, the Working Group

on Sustainability was established in ICOM “to consider how to mainstream the UN Sustainable Development Goals and the Paris Agreement across its range of activities,” which includes supporting museums to accomplish the goals of Agenda 2030 [80]. In accordance with Chris Landorf [72] (p. 495), despite the existence of various approaches to sustainable development, the common principles are the “long-term and holistic planning process, and the active participation of multiple stakeholders,” which involve balancing acts [57]. Giannini and Bowen [20] (p. 199) put forward an important question related to our current post-digital circumstance and sustainability: “museums are now asking, what will be a sustainable model of the future under the impact of the emerging principles of digitality?” This paper shows that it is important to start looking inward at the sustainability of digital practices in museums and consider this as part of long-term and holistic planning.

There is emerging museum literature and guidelines showing how digital technologies can be unpredictable, or how they can enable or hinder sustainable development, with a growing awareness of the ethical implications of digital technologies in terms of human agency, fairness, security, and representation [67,81,82]. The nexus of digital literacy and ethics is a valuable resource for each museum to address the sustainability of their digital practices based on their own contingent circumstances. New museum ethics advocate for museums to “participate in creating a more just and equitable society” [83] (p. 7). For Janet Marstine et al. [84] (p. 70), new museum ethics is a social practice of self-reflexivity and transparency that provides the lens through which to engage constantly with the world and build trust with people. Marstine et al. [84] (p. 91) further argue that “engaging in the new museum ethics is a twenty-first-century skill that museum and museum studies leaders must build among students, professionals, and communities.” Nevertheless, the consideration of ethics and digital technologies in the museum literature has not been extensive, even though museum professionals engage every day with ethical questions in their digital activities, for example, in terms of valuing user contributions, managing risks, and negotiating power [85]. Much work has focused on building the digital literacy and digital capacities of museum professionals to better evaluate “digital” and what it means for museums. Different projects examined digital competencies in museum professionals in relation to challenges and how these can be enhanced to enable the efficient digitalisation of museums [60,63,86]. The One by One: Building Digital Literacies (2017–2020) project advocates for digital literacy that looks beyond “functional IT skills to describe a richer set of digital behaviours, practices and identities” [63] (preface) instead of solely equating digital skills to technical skills that museums can be equipped with to engage in digital projects. As noted by the researchers of the One by One project, this equation will lead to a “skills supply of finite technical competencies that are limited in how flexibly they can be deployed across tasks and roles, which then leads to siloed skill deployment and comparatively narrowly conceived traditional forms of training and development” [63] (p. 34).

The nexus of digital literacy and ethics can act as a valuable resource for each museum to address the impact and sustainability of their digital practices based on their own contingent circumstances. The ethical and social dimensions of human–nature relationships in museums have often been minimised in favour of economic and technical metrics in sustainability discussions [87]. This is evident in the studies reviewed in this paper, as the challenges associated with the implementation of digital activities are considered in terms of technical, financial, and knowledge capacities without further consideration of the impact these practices have on societies. It is here that the post-digital concept becomes all the more relevant as it gives space for reflection and problematization on the “ontological reconfiguration of the role of institutions that are now understood as rhizomatic assemblages of data and things—multi-temporal, multi-spatial, and multi-agent” [32] (p.29). This ontological reconfiguration raises ethical questions for the museum and how it stands as an institution in a sociotechnical and physical world characterised by a radical expansion of connectivity, time, and space. It is necessary for museums to redefine themselves within this complex global context of more-than-human crises and sociotechnical systems where discussions have moved beyond binaries such as “analogue” (considered as traditional,

slow) versus “digital” (considered as having inclusive rhetoric, speed) [40,88]. Of particular relevance to this discussion are the rules formulated by a group of computer scientists in 2010 pertaining to “Moral Responsibility for Computing Artifacts” [89] because they include the sociotechnical systems in which technological artefacts are embedded and their impact as an important part of the ethical framework of technologies.

This comes with urgency in the context of the climate crisis era we live in and the recent calls for transparency and accountability in museums [90]. It entails a multidimensional understanding and knowledge that can help us evaluate why we are using technologies and how to be, in Ross Parry’s words [91] (p. 34), “digitally purposeful.” Adopting and implementing digital technologies will require a deep understanding and justification of their impact on communities, planetary limits, and the environment more broadly. These ethical considerations can provide guidance to clarify thought and action in the post-digital museum. In other words, it is an understanding that, as Zuanni [9] (p. 71) explained, the “possibilities to address challenges in the digital transformation will vary between museums of different sizes, administrative status, and geographical location, so that each museum will need to find a balance satisfying its audience needs, its digital capabilities, and its mission” and to add its impact to what Leoni and Cristofaro have termed the “co-evolutionary organization-environment relationship” [16] (p. 16). Finally, this paper is aligned with this growing literature advocating for a holistic, ethical, and sustainable digital transformation of museums. This means to make a “renewed commitment to ethical—and—just digital heritage practices” [92] (p. 45) by pursuing further research and reflective action on how museum professionals can be empowered to make this the norm in museums.

This is of crucial importance for the future of museums in this context of the rapid transformation and diffusion of digital technologies in societies and the sustainability implications of the “digital.” The relationship between museum ethics, as value judgements situated in specific socio-temporal contexts [93], and digital literacy can become the cornerstone of the digitalisation of museums in that it can allow professionals to engage critically with technologies—to paraphrase Damala et al. [8] (p. 19)—“rather than stare at it” and, instead, see it as a “muse rather than a calamity” in the redefinition of the museums’ role in societies. Sebastian Chan, in his keynote speech at the ICOM Kyoto Congress [26], posited a thought-provoking question on digital transformation: “Who do you partner with to achieve this ethically, sustainably, and in the least extractive manner?” This is a question for museum professionals and academic researchers to deeply explore and reflect on since technologies are in a constant state of being, creating new dynamics and relationships at every moment [27] (p. 10).

5. Conclusions

This paper reviewed a diverse typology of resources to examine the challenges museum professionals face in their digital practices. Addressing the rapid technological, social, and economic transformations—even during health crises—is a constant challenge for museums, whose business model was created almost two hundred years ago. We live in a post-digital era where digital technologies have a normative presence (in different scales) in societies and in a post-COVID-19 period where the “digital pivot” in museums has already occurred. Now, it is important to address the question of the sustainability of the digital pivot that took place in museums during the pandemic. This review has shown that systemic problems exist in the “backstage” of museums across Europe pertaining to organisational and technical aspects of digitalisation, albeit varying in extent. These systemic problems relate to knowledge and skills, consideration of digital technologies as an add-on to museum practices, and deficits in human and financial resources. Operating in this context, museums seem to jump into digital transformation, leading to a continuous cycle of adopting and abandoning technologies without considering the impact of this practice. Two interconnected aspects of sustainability in museum digital practices come to the fore here: one that is inward-looking and one that is outward-looking. The inward-looking aspect is about the sustainability of digital activities and their technical minefield, which

is related to the life cycle of digital technologies and the rapid rate at which we go from adoption to maintenance, obsolescence, and, finally, abandonment of digital technologies. The outward-looking aspect concerns the impact digital technologies have on the social and physical environment of museums on a local and global scale.

Considering how digital technologies are assemblages of hardware and software depending on global internet traffic and infrastructure operating on the extraction of non-renewable materials, human labour, and data, the two aspects of sustainability in museum digital practices raise ethical questions related to power, climate crisis, access, and inequality. This ethical dimension provides the link between the two aspects of sustainability in the digitalisation of museums, as it connects museum values and the position a museum wants to take in the world it stands in with the technical minefield of digital technologies. The dialogic relationship between sustainability and ethics, as shown in this essay, has the potential to contribute to the creation of a “digitally purposeful” museum and, in turn, to a holistic digital transformation of museums in the post-digital era since it can be a framework in which to consider, in conjunction, (a) the sociotechnical context of digital technologies and their impact on humans and nature, (b) the ontological reconfiguration of museums as rhizomatic assemblages of data, things, humans, and non-humans, and (c) museum values and organisational culture. In other words, this relational understanding of ethics and sustainability can be a pivotal first step towards ongoing, deep, and reflective research into different kinds of metrics, skills, resources, the more-than-human, ecology, and the relationship between museum professionals and researchers for forming a digitally purposeful museum in the post-digital era.

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References

1. Ådahl, S.; Nikolaou, P.; Asimenou, M. Focus Group Phase 2 Report. Available online: <https://cordis.europa.eu/project/id/101004545/results> (accessed on 6 February 2024).
2. Vial, G. Understanding digital transformation: A review and a research agenda. *J. Strateg. Inf. Syst.* **2019**, *28*, 118–144. [CrossRef]
3. The Digital Transformation Agenda and GLAMs—Culture24, Findings and Outcomes. Available online: <https://pro.europeana.eu/post/the-digital-transformation-agenda-and-glams-culture24-findings-and-outcomes> (accessed on 6 February 2024).
4. Europeana Pro. Building Digital Capacity. Available online: <https://pro.europeana.eu/page/building-digital-capacity> (accessed on 6 February 2024).
5. Parry, R. The End of the Beginning. *Mus. Worlds* **2013**, *1*, 24–39. [CrossRef]
6. Mason, M. The Contribution of Design Thinking to Museum Digital Transformation in Post-Pandemic Times. *Multimodal Technol. Interact.* **2022**, *6*, 79. [CrossRef]
7. Shehade, M.; Stylianou-Lambert, T. Virtual Reality in Museums: Exploring the Experiences of Museum Professionals. *Appl. Sci.* **2020**, *10*, 4031. [CrossRef]
8. Damala, A.; Ruthven, I.; Hornecker, E. The MUSETECH model: A comprehensive evaluation framework for museum technology. *J. Comput. Cult. Herit.* **2019**, *12*, 1–22. [CrossRef]
9. Zuanni, C. Museum connections during the COVID-19 pandemic. *AJPA* **2022**, *4*, 63–72. [CrossRef]
10. Zuanni, C. Heritage in a digital world. Algorithms, data and future value generation. *Limina* **2020**, *3*, 236–259. [CrossRef]
11. Parry, R.; Eikhof, D.R.; Barnes, S.A.; Kispeter, E. Development, supply, deployment, demand: Balancing the museum digital skills ecosystem: First findings of the “One by One” national digital literacy project. In Proceedings of the Museums and the Web 2018, Vancouver, BC, Canada, 18–21 April 2018; Available online: <https://mw18.mwconf.org/paper/development-supply-deployment-demand-balancing-the-museum-digital-skills-ecosystem-first-findings-of-the-one-by-one-national-digital-literacy-project/> (accessed on 6 February 2024).

12. International Council of Museums—ICOM 2021. Museums, Museum Professionals and COVID-19. A Follow-Up Survey. Available online: https://icom.museum/wp-content/uploads/2020/11/FINAL-EN_Follow-up-survey.pdf (accessed on 6 February 2024).
13. Network of European Museum Organisations—Nemo 2021. Follow-Up Survey on the Impact of the COVID-19 Pandemic on Museums in Europe. Final Report. Available online: https://www.ne-mo.org/fileadmin/Dateien/public/NEMO_documents/NEMO_COVID19_FollowUpReport_11.1.2021.pdf (accessed on 6 February 2024).
14. NESTA & ACE 2019. Digital Culture. 2019. Available online: <https://media.nesta.org.uk/documents/Digital-Culture-2019.pdf> (accessed on 6 February 2024).
15. Taormina, F.; Baraldi, S.B. Museums and digital technology: A literature review on organizational issues. *Eur. Plan. Stud.* **2022**, *30*, 1676–1694. [[CrossRef](#)]
16. Leoni, L.; Cristofaro, M. To adopt or not to adopt? A coevolutionary framework and paradox of technology adoption by small museums. *Curr. Issues Tour.* **2022**, *18*, 1–22. [[CrossRef](#)]
17. Marty, P.F.; Buchanan, V. Exploring the Contributions and Challenges of Museum Technology Professionals during the COVID-19 Crisis. *Curator* **2022**, *6*, 117–133. [[CrossRef](#)]
18. Macdonald, S. *Behind the Scenes at the Science Museum*, 1st ed.; Berg: Oxford, UK, 2002.
19. Morse, N.; Rex, B.; Harvey, S. Editorial: Methodologies for Researching the Museum as Organization. *Mus. Soc.* **2018**, *16*, 112–123. [[CrossRef](#)]
20. Giannini, T.; Bowen, J.P. Museums and Digital Culture: From Reality to Digitality in the Age of COVID-19. *Heritage* **2022**, *5*, 11. [[CrossRef](#)]
21. Li, C.; Ghirardi, S. The role of collaboration in innovation at cultural and creative organisations. The case of the museum. *Mus. Manag. Curatorsh.* **2019**, *34*, 273–289. [[CrossRef](#)]
22. Simon, N. *The Participatory Museum*; Museum 2.0: Santa Cruz, CA, USA, 2010.
23. Museum Definition International Council of Museums. Available online: <https://icom.museum/en/resources/standards-guidelines/museum-definition/> (accessed on 6 February 2024).
24. Martins, L.C.; Martins, D.L.; do Carmo, D. Connected Museums: Reflections on Constructing Technology Maturity Parameters in Museums. *Curator* **2021**, *64*, 585–600. [[CrossRef](#)]
25. Weil, S. From Being about Something to Being for Somebody: The Ongoing Transformation of the American Museum. *Daedalus* **1999**, *128*, 229–258. Available online: <http://www.jstor.org/stable/20027573?origin=JSTOR-pdf> (accessed on 4 March 2024).
26. Chan, S. Museum Technology Keynote—Words from ICOM 2022 Prague. Available online: <https://sebchan.medium.com/museums-and-technology-a-gentle-provocation-b9992c2e4455> (accessed on 6 February 2024).
27. Bounia, A.; Catapoti, D. Introduction: Emerging Technologies and Cultural Heritage. In *Emerging Technologies and Cultural Heritage*, 1st ed.; Bounia, A., Catapoti, D., Eds.; Alexandria: Athens, Greece, 2022; pp. 9–24. (In Greek)
28. Bounia, A. Museums and Cultural Organizations in a «Post-Digital World»: Challenges and Opportunities. In *Emerging Technologies and Cultural Heritage*, 1st ed.; Bounia, A., Catapoti, D., Eds.; Alexandria: Athens, Greece, 2022; pp. 197–218. (In Greek)
29. Stalder, F. *The Digital Condition*; Translated by Valentine Pakis. English Edition; Polity Press: Medford, MA, USA, 2017.
30. Russo Spena, T.; Bifulco, F. (Eds.) *Digital Transformation in the Cultural Heritage Sector. Challenges to Marketing in the New Digital Era*, 1st ed.; Springer: Cham, Switzerland, 2021. [[CrossRef](#)]
31. Giannini, T.; Bowen, J.P. (Eds.) *Museums and Digital Culture. New Perspectives and Research*, 1st ed.; Springer: Cham, Switzerland, 2019. [[CrossRef](#)]
32. Bounia, A. New Directions in the Future of Heritage Institutions: The Post-digital Museum. *Int. J. Commun. Linguist. Stud.* **2023**, *21*, 19–34. [[CrossRef](#)]
33. Malde, S.; Kennedy, A.; Parry, R. Understanding the Digital Skills and Literacies of UK Museum People—Phase Two Report. University of Leicester. 2019. Available online: https://leicester.figshare.com/articles/report/Understanding_the_digital_skills_literacies_of_UK_museum_people_Phase_Two_Report/10196294 (accessed on 4 March 2024).
34. Kidd, J.; Nieto McAvoy, E.; Ostrowska, A. Implications of the COVID-19 Digital ‘Pivot’ in Museums and Galleries: Lessons from Practitioners. AHRC Policy and Evidence Center, Cardiff University. Available online: <https://www.pec.ac.uk/discussion-papers/pivot-to-digital-how-museums-and-galleries-responded-to-covid-19> (accessed on 4 March 2024).
35. Proctor, N. The Museum as Distributed Network. 2010. Available online: <https://museum-id.com/museum-distributed-network-21st-century-model-nancy-proctor/> (accessed on 6 February 2024).
36. Balsamo, A.; Bautista, S.S. Understanding the Distributed Museum: Mapping the Spaces of Museology in Contemporary Culture. Available online: https://www.museumsandtheweb.com/mw2011/papers/understanding_the_distributed_museum_mapping_t.html (accessed on 6 February 2024).
37. Rodley, E. The Distributed Museum is Already Here. It’s just not very evenly distributed. In *The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites*, 1st ed.; Lewi, H., Smith, W., vom Lehn, D., Cooke, S., Eds.; Routledge: London, UK, 2019; pp. 81–91. [[CrossRef](#)]
38. Dewdney, A.; Dibosa, D.; Walsh, V. *Post Critical Museology: Theory and Practice in the Art Museum*; Routledge: London, UK, 2013.
39. Osbourne, P. *Anywhere or Not at All*; Verso: London, UK, 2013.

40. Witcomb, A. Afterword. In *The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites*, 1st ed.; Lewi, H., Smith, W., vom Lehn, D., Cooke, S., Eds.; Routledge: London, UK, 2019; pp. 484–487. [CrossRef]
41. Maye, L.A.; Bouchard, D.; Avram, G.; Ciolfi, L. Supporting Cultural Heritage Professionals Adopting and Shaping Interactive Technologies in Museums. In *Proceedings of the 2017 Conference on Designing Interactive Systems*, Edinburgh, UK, 10–14 June 2017; ACM: New York, NY, USA, 2017; pp. 221–232. [CrossRef]
42. Cerquetti, M. More is better! Current Issues and Challenges for Museum Audience Development: A Literature Review. *ENCATC J.* **2016**, *6*, 30–95. [CrossRef]
43. Kirova, V. Value co-creation and value co-destruction through interactive technology in tourism: The case of ‘La Cité du Vin’ wine museum, Bordeaux, France. *Curr. Issues Tour.* **2021**, *24*, 637–650. [CrossRef]
44. Carvajal-Trujillo, E.; Molinillo, S.; Liébana-Cabanillas, F. Determinants and risks of intentions to use mobile applications in museums: An application of fsQCA. *Curr. Issues Tour.* **2021**, *24*, 1284–1303. [CrossRef]
45. Marty, P.F. Finding the Skills for Tomorrow: Information Literacy and Museum Information Professionals. *Mus. Manag. Curatorship* **2006**, *21*, 317–335. [CrossRef]
46. Dewdney, A. The networked image. The flight of cultural authority and the multiple times and spaces of the art museum. In *The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites*, 1st ed.; Lewi, H., Smith, W., vom Lehn, D., Cooke, S., Eds.; Routledge: London, UK, 2019; pp. 68–80. [CrossRef]
47. Museums around the World in the Face of COVID-19. UNESCO 2020. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000373530> (accessed on 6 February 2024).
48. Noehrer, L.; Gilmore, A.; Jay, C.; Yehudi, Y. The impact of COVID-19 on digital data practices in museums and art galleries in the UK and the US. *Hum. Soc. Sci. Commun.* **2021**, *8*, 1–10. [CrossRef]
49. Larkin, J.; Ballatore, A.; Mityurova, E. Museums, COVID-19 and the pivot to social media. *Curator* **2023**, *66*, 629–646. [CrossRef]
50. Morse, C.; Landau, B.; Lallemand, C.; Wieneke, L.; Koenig, V. From #MuseumAtHome to #AtHomeAtTheMuseum: Digital Museums and Dialogical Engagement Beyond the COVID-19 Pandemic. *ACM J. Comput. Cult. Herit.* **2022**, *15*, 1–29. [CrossRef]
51. De las Heras-Pedrosa, C.; Iglesias-Sánchez, P.P.; Jambrino-Maldonado, C.; López-Delgado, P.; Galarza-Fernández, E. Museum communication management in digital ecosystems. Impact of COVID-19 on digital strategy. *Mus. Manag. Curatorsh.* **2023**, *38*, 548–570. [CrossRef]
52. Agostino, D.; Arnaboldi, M.; Diaz Lema, M. New development: COVID-19 as an accelerator of digital transformation in public service delivery. *Public Money Manag.* **2021**, *41*, 69–72. [CrossRef]
53. Choi, B.; Kim, J. Changes and Challenges in Museum Management after the COVID-19 Pandemic. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 148. [CrossRef]
54. Kidd, J.; Nieto McAvoy, E.; Ostrowska, A. Negotiating hybridity, inequality, and hyper-visibility: Museums and galleries’ social media response to the COVID-19 pandemic. *Cult. Trends* **2024**, *33*, 19–36. [CrossRef]
55. Zuanni, C. Mapping Museum Digital Initiatives during COVID-19. 2020. Available online: <https://pro.europeana.eu/post/mapping-museum-digital-initiatives-during-covid-19> (accessed on 4 March 2024).
56. Galani, A.; Kidd, J. Evaluating Digital Cultural Heritage ‘In the Wild’: The Case For Reflexivity. *ACM J. Comput. Cult. Herit.* **2019**, *12*, 1–15. [CrossRef]
57. Parry, R.; Djiekan, V. Critical Digital: Museums and their Postdigital Circumstance. In *Art, Museums & Digital Cultures: Rethinking Change*, 1st ed.; Barranha, H., Simoes Henriques, J., Eds.; Universidade NOVA de Lisboa & maat: Lisboa, Portugal, 2021; pp. 16–26.
58. ICOM. Museums, Museum Professionals and COVID-19: 3rd Survey. 2021. Available online: https://icom.museum/wp-content/uploads/2021/07/Museums-and-Covid-19_third-ICOM-report.pdf (accessed on 6 February 2024).
59. Carvalho, A.; Matos, A. Museum Professionals in a Digital World: Insights from a Case Study in Portugal. *Mus. Int.* **2018**, *70*, 34–47. [CrossRef]
60. MuSA. Museum Professionals in the Digital Era. *Agents of Change and Innovation.* 2017. Available online: <http://www.project-musa.eu/wp-content/uploads/2017/03/MuSA-Museum-professionals-in-the-digital-era-full-version.pdf> (accessed on 6 February 2024).
61. Price, K.; Dafydd, J. Structuring for Digital Success: A Global Survey of How Museums and Other Cultural Organizations Resource, Fund, and Structure Their Digital Teams and Activity. 2018. Available online: <https://mw18.mwconf.org/paper/structuring-for-digital-success-a-global-survey-of-how-museums-and-other-cultural-organisations-resource-fund-and-structure-their-digital-teams-and-activity/index.html> (accessed on 6 February 2024).
62. De Bernardi, P.; Bertello, A.; Shams, R. Logics Hindering Digital Transformation in Cultural Heritage Strategic Management: An Exploratory Case Study. *Tour. Anal.* **2018**, *24*, 315–327. [CrossRef]
63. Parry, R.; Eikhof, D.R.; Barnes, S.; Kispeter, E. Mapping the Museum Digital Skills Ecosystem—Phase One Report. University of Leicester. 2018. Available online: https://figshare.le.ac.uk/articles/report/Mapping_the_Museum_Digital_Skills_Ecosystem_-_Phase_One_Report/10228520 (accessed on 6 February 2024).
64. Parry, R. The Practice of Digital Heritage and the Heritage of Digital Practice. In *Museums in a Digital Age*, 1st ed.; Ross, P., Ed.; Routledge: London, UK, 2010; pp. 1–7. [CrossRef]

65. McDermott, F.; Clarke, L.; Hornecker, E.; Avram, G. Challenges and opportunities faced by cultural heritage professionals in designing interactive exhibits. In Proceedings of the NODEM Conference, Stockholm, Sweden, 1–3 December 2013; pp. 19–26. Available online: <https://nodem.org/wp-content/uploads/2015/09/NODEM2013Proceedings.pdf> (accessed on 6 February 2024).
66. Cameron, F.R. Theorising heritage collection digitisations in global computational infrastructures. In *The Routledge International Handbook of New Digital Practices in Galleries, Libraries, Archives, Museums and Heritage Sites*, 1st ed.; Lewi, H., Smith, W., vom Lehn, D., Cooke, S., Eds.; Routledge: London, UK, 2019; pp. 55–67. [CrossRef]
67. Sacco, P.; Gargano, E.R.; Cornella, A. Sustainable Digitalization: A Systematic Literature Review to Identify How to Make Digitalization More Sustainable. In Proceedings of the 21st International TRIZ Future Conference Creative Solutions for a Sustainable Development, Bolzano, Italy, 22–24 September 2021; pp. 14–29. [CrossRef]
68. Linkov, I.; Trump, B.D.; Poinsatte-Jones, K.; Florin, M.-V. Governance Strategies for a Sustainable Digital World. *Sustainability* **2018**, *10*, 440. [CrossRef]
69. United Nations. Report of the World Commission on Environment and Development: Our Common Future. 1987. Available online: <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf> (accessed on 6 February 2024).
70. Stylianou-Lambert, T.; Boukas, N.; Christodoulou-Yerali, M. Museums and cultural sustainability: Stakeholders, forces, and cultural policies. *Int. J. Cult. Policy* **2014**, *20*, 566–587. [CrossRef]
71. Darlow, S.; Essex, S.; Brayshay, M. Sustainable heritage management practices at visited heritage sites in Devon and Cornwall. *J. Herit. Tour.* **2012**, *7*, 219–237. [CrossRef]
72. Landorf, C. A Framework for Sustainable Heritage Management: A Study of UK Industrial Heritage Sites. *Int. J. Herit. Stud.* **2009**, *15*, 494–510. [CrossRef]
73. Müller, M.; Grieshaber, J. The Sustainability Start, A Model for Museums. ICOM Voices. 2023. Available online: <https://icom.museum/en/news/the-sustainability-star-a-model-for-museums/> (accessed on 6 February 2023).
74. Giliberto, F.; Labadi, S. Harnessing cultural heritage for sustainable development: An analysis of three internationally funded projects in MENA Countries. *Int. J. Herit. Stud.* **2021**, *28*, 133–146. [CrossRef]
75. Orea-Giner, A.; De-Pablos-Heredero, C.; Trinidad Vacas, G. Sustainability, economic value and socio-cultural impacts of museums: A theoretical proposition of a research method. *Mus. Manag. Curatorship* **2019**, *36*, 48–61. [CrossRef]
76. Loach, K.; Rowley, J.; Griffiths, J. Cultural sustainability as a strategy for the survival of museums and libraries. *Int. J. Cult. Policy* **2017**, *23*, 186–198. [CrossRef]
77. Garthe, C.J. *The Sustainable Museum How Museums Contribute to the Great Transformation*, 1st ed.; Routledge: London, UK, 2023. [CrossRef]
78. Friedman, A.J. The Great Sustainability Challenge: How Visitor Studies Can Save Cultural Institutions in the 21st Century. *Visit. Stud.* **2007**, *10*, 3–12. [CrossRef]
79. Brown, K. Museums and Local Development: An Introduction to Museums, Sustainability and Well-being. *Mus. Int.* **2019**, *71*, 1–13. [CrossRef]
80. ICOM Working Group on Sustainability. Available online: <https://icom.museum/en/news/get-to-know-icom-wgs/>; (accessed on 6 February 2024).
81. Sollie, P. Ethics, technology development and uncertainty: An outline for any future ethics of technology. *J. Inf. Commun. Ethics Soc.* **2007**, *5*, 293–306. [CrossRef]
82. European Commission. Available Ethics Guidelines for Trustworthy AI. High-Level Expert Group on AI. Available online: <https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai> (accessed on 6 February 2024).
83. Kreps, C. Appropriate museology and the “new museum ethics”. Honoring diversity. *Nord. Museol.* **2015**, *2*, 4–16. [CrossRef]
84. Marstine, J.; Dodd, J.; Jones, C. Reconceptualizing Museum Ethics for the Twenty-First Century—A view from the Field. In *The International Handbooks of Museum Studies*, 1st ed.; MacCarthy, C., Ed.; John Wiley & Sons: Chichester, West Sussex, 2015; pp. 69–96. [CrossRef]
85. Kidd, J. Digital media ethics and museum communication. In *The Routledge Handbook of Museums, Media and Communication*, 1st ed.; Drotner, K., Dziekan, V., Parry, R., Schröder, K.C., Eds.; Routledge: London, UK, 2018; pp. 193–204. [CrossRef]
86. DigiCulture 2021. Digital Culture. Improving the Digital Competences and Social Inclusion of Adults in Creative Industries. Available online: <https://digidculture.eu/en/outputs/> (accessed on 6 February 2024).
87. Samuel, G.; Lucivero, F.; Somavilla, L. The Environmental Sustainability of Digital Technologies: Stakeholder Practices and Perspectives. *Sustainability* **2022**, *14*, 3791. [CrossRef]
88. Cramer, F.; Jandrić, P. Postdigital: A Term That Sucks but Is Useful. *Postdigit. Sci. Educ.* **2021**, *3*, 966–989. [CrossRef]
89. Koenitz, H.; Barbara, J.; Bakk, A.K. An Ethics Framework for Interactive Digital Narrative Authoring. In *The Authoring Problem*, 1st ed.; Hargood, C., Millard, D.E., Mitchell, A., Spierling, U., Eds.; Human–Computer Interaction Series; Springer: Cham, Switzerland, 2022. [CrossRef]
90. ASSEMBLY: A New Conversation about Museum Research. Available online: <https://amaga.org.au/Web/Web/News/Articles/ASSEMBLY--A-New-Conversation-about-Museum-Research.aspx> (accessed on 6 February 2023).
91. Parry, R. Socially Purposeful Digital Skills. In *Let's Get Real 6: Connecting Digital Practice with Social Purpose. Report from the 6th Culture24 Action Research Project*; Culture24: London, UK; pp. 34–35. Available online: <https://www.keepandshare.com/doc/8226734/let-s-get-real-6-culture-24-rgb-single-page-pdf-10-5-meg?da=y> (accessed on 7 February 2024).

92. Kidd, J. Keynote Speech: Being Ethical in Digital Cultural Heritage Practice. In Proceedings of the RISE IMET 2021, Virtual Conference, Emerging Technologies and the Digital Transformation of Museums and Heritage Sites, Nicosia, Cyprus, 2–4 June 2021; Available online: https://cyprusconferences.org/riseimet2021/wp-content/uploads/2021/06/RISE-IMET-Book-of-Abstracts-10_06_2021.pdf (accessed on 6 February 2024).
93. Gazi, A. Exhibition Ethics—An Overview of Major Issues. *J. Conserv. Mus. Stud.* **2014**, *12*, 1–10. [[CrossRef](#)]

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THE IMPACT OF VIRTUAL TOURS ON MUSEUM EXHIBITIONS AFTER THE ONSET OF COVID-19 RESTRICTIONS: VISITOR ENGAGEMENT AND LONG TERM PERSPECTIVES

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Abstract

After the outbreak of Covid-19, galleries and museums have been experimenting with new ways to engage a potential audience remotely. This study focuses on the level of engagement of virtual tours in museums looking at the representation of architectural space, representation artifacts, and ease of use as possible correlated factors. A sample group of eighty early-career experts in the field of art, architecture, or design assessed their visit to the archaeological museum of Troya Müzesi in Çanakkale, Turkey; half of the participants resided in Turkey, while the other half in Italy. This paper has addressed the following research questions with an online multi-level study: how is the online exhibition platform evaluated by its audience? Can regular employment of virtual tours engage new visitors in the long term? Is the representation of a museum, in the form of a virtual twin, an adequate surrogate that creates an immersive visiting experience?

Keywords

Virtual tour, digital twin, online exhibition, engagement, museum digitization

1. Introduction

After the outbreak of Covid-19, galleries and museums have been experimenting with new ways to engage a potential audience remotely. On one hand is the necessity to address regular visitors with loyalty marketing initiatives, on the other is the competition to attract new visitors on a global scale. Online exhibition platforms have been instrumental for this purpose, accelerating a process that has been in the making for the last two decades. China, being the first country that operated lockdowns on a larger scale, has experimented with diffused virtual exhibitions in advance. Feng (2020) records initial spontaneous practices triggered by self-organized groups via social media, and their struggle with limitation of freedom of expression at a later stage. Responses on an institutional level tackled the issue of online interaction with manifold strategies of communication, eventually leading to talks and virtual tours with curators, online artist performances, special guests, virtual opening, and happy hours. According to a survey by the Network of European Museum Organisations –

NEMO, collecting 1000 responses from museums across 48 countries in March-April 2020, museums reported a loss of income of 75-80% and greater economic vulnerability for those that rely on private funding (Network of European Museum Organisations - NEMO, 2020, p. 2). This situation led to a reallocation of staff to digital services, to the point that half of the museums now offer at least one or more new online services, and two out of five registered a consistent increase of online visits in the range of 10% to 150%. In brief, evidence support that “museums online are important extensions and complements of physical museums, but that a sound metric to benchmark online visits is missing” (Network of European Museum Organisations - NEMO, 2020, p. 3). NEMO (2021) also published a follow-up survey after Covid-19 restrictions had been relaxed during the summer and then reimposed towards the end of the year. This second mandated closure, “without consultation”, caused a greater hit as 70% of the museums have not been able to set a re-opening date. The landmark problem is that the economic base of a museum is ticketing, and diversified sources of outcome were not ready

to support a general drop of visits due to the halt to global tourism. Although online services can be seen as the preferable secondary strategy, “Over 8 in 10 museums suggested that they require additional support with digital tools and transition. Of those museums, over 40% of the museums responded requiring assistance with building a digital strategy” (Network of European Museum Organisations - NEMO, 2021, p. 5). The increased budget allocated to online presence and communication, the willingness to explore innovative digital technique, and the unprecedented production of video content, contrasted with a lack of digital literacy and, most importantly for the scope of our study, no methodology to track the success of their digital strategies (Network of European Museum Organisations - NEMO, 2021).

In this framework, one-third of the museums of the NEMO report developed a virtual tour experience. The unexpected condition of a pandemic functioned as a catalyst to start a reaction of virtualisation of art and its mechanism of enjoyment. This study will address the aforementioned issues by looking at the potential of virtual tours for museums in emergency scenarios, and additionally consider a long-term adoption of virtual tours as a fundamental strategy for global visitors’ engagement.

Most of the online platforms are based on a predesigned template that can be customised with different contents. Some platforms provide 360° panorama pictures only, some allow to move between hotspots and explore a 3d modelled space, others provide maximum freedom in terms of movements. The latter is usually compatible with VR headsets and has created new hybrid applications in which videogames technologies are used in museum contexts. This is spearheading a new dimension of the heritage sector under the name gamification (Hammady, Ma, & Temple, 2016). However, serious games require advanced hardware and software, and an expert operator. For this reason, museums opted for more traditional human-computer interaction via virtual platforms. Inputs are based on mouse clicking, drag and drop, point of view orbiting with a pointer, keyboard typing, panning to move the visual, and so on. Even though these operations are unnatural, they have been employed for a long time and are paradoxically more accessible for regular computer users. Hence, the environment of an online museum visit is a complex blending of

artistic content, appropriateness, quality of the architecture of the platform, and human-machine interaction mechanism. In order to explore these issues, we will pose the following questions: how is the online exhibition platform evaluated by its audience? Can regular employment of virtual tours engage new visitors in the long term? Is the representation of a museum, in the form of a virtual twin, an adequate surrogate that creates an immersive visiting experience? This paper has addressed these questions with an online multi-level study. Whether the use of virtual tours will be a permanent effect, or not, on the digitization spurred by the pandemic is beyond the scope of the present paper. We have focused the study on the user experience and appreciation using a targeted group in order to have expert opinions.

The analysed virtual tour museum framework can be described as shown in the following figure (Figure 1).

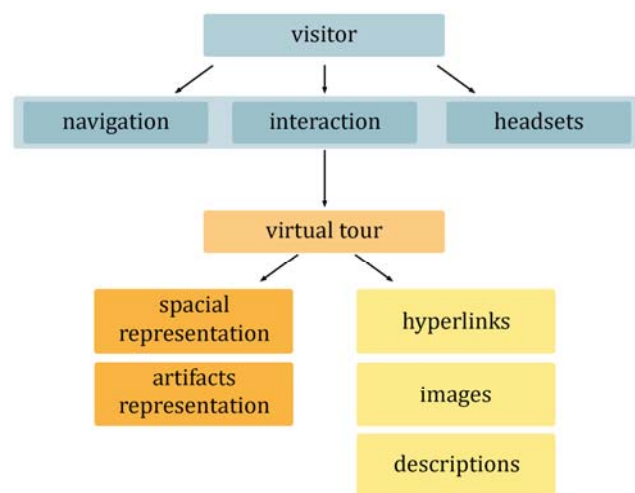


Fig. 1: Virtual tour museum framework

2. Literature review

2.1 Interactive platforms in exhibition design

This study has been developed from a pilot research, on a small sample group, already published by the authors as a book chapter (Karacan & Resta, 2020). In the conclusions, the authors gathered provisional data on virtual exhibition platforms that have been verified and consolidated in this article with a new survey. Hammady, Ma, and Temple (2016) suggest the importance of a survey to explore the effectiveness of augmented reality in museums. The same authors have recently published a study on the

acceptance of Mixed Reality (MR) devices, at the Museum of Manchester, which indicates that willingness for future use is the most relevant response from the visitors (Hammady, Ma, & Strathearn, 2020). Namely, the cognitive response via perceived ease of use assessment and external stimuli via engagement assessment. Kabassi, Amelio, Komianos, & Oikonomou (2019) propose a methodology of evaluation of museum virtual tours that uses a combination of two multi-criteria decision-making theories, the analytic hierarchy process (AHP) and the fuzzy technique for order of preference by similarity to ideal solution (TOPSIS). Kabassi (2017) also outlined the state of the art on the most relevant evaluation experiments with online museum visitors. Methodologies have been categorized in inspection methods, empirical methods, and participation of both real and expert users. It is suggested that experts should be sourced both on usability, Virtual Tour in our case, and domain experience: here exhibition and exhibition design. Hence, on the one hand, evaluation may focus on alternative user interaction systems (Argyriou, Economou, & Bouki, 2020; Barbieri, Bruno, & Muzzupappa, 2017), while on the other, on the museum perspective. El-Said & Aziz (2021) have recently analyzed virtual tour's role in the frame of post-Covid-19 recovery of cultural industry, investigating the intention to adopt VTs. They integrated together the Protective Action Decision Model (PADM) and the Technology Acceptance Model (TAM).

A virtual museum is generally considered as an information system comprising a collection of digitized objects, enriched with metadata, that can be experienced in a digital space (Povroznik, 2018). The earliest applications of virtual museums appeared after 1990 on CD-ROM supports. Huhtamo (2010) has analysed historical precedents of virtual museums, in the field of exhibition design and interactive media art, and highlighted the long-lasting challenges of virtual museums on which we have based the purposes of the study:

- Can tele-tactility replace the physical touch and the material perception of the objects?
- Is the interface valid and easy to use?
- What is the threshold of attention for a virtual visitor?
- Can the experience communicate contents appropriately? Does the entertainment aspect of the application distract the user?

- What is the relationship between virtual and physical museums?
- Is user interaction with the exhibition important?
- What degree of freedom does the user need in a virtual museum?

The evolution of the digital museum experience is intertwined with that of the technology that enables it (Povroznik, 2020). But this convergence can be interpreted also as the natural outcome of media art gradually choosing the virtual as the preferred venue for creative experimentation (Luo, Shedd, & Nanetti, 2018). Hence, in terms of museum strategy, physical and virtual exhibitions are hardly overlapping domains.

The creation of the *Google Art Project*, in 2011, caused a momentous shift towards the spreading of virtual tours for museums. Bonacini (2015) examined the importance of the Google initiative, especially for archaeological museums which is also the typology of museums that this study will tackle. Archaeological sites are often located in remote locations, as the Troya Müzesi is in the middle of the Troy National Park, and the use of virtual tours can help potential visitors to have a first visual approach with what could become a physical visit at a later stage.

This transformation encouraged museums to abandon the idea of accompanying the visits with lecture-like explanations. Museum spaces are being opened by technology, as James Bradburne argues in his foreword to the volume *Digital technologies and the museum experience*, and “these days, the motivated visitor can arguably reconfigure a gallery visit to meet his or her own specific needs—with or without the museum’s help” (Tallon & Walker, 2008, p. X). This two-way dialogue, in which the visitor has the ability to follow a personal path, is augmented with multimedia content as additional layers of information. Complimentary narration expands the involvement of an interested beholder fostering the level of the intellectual bond between the visitor and the exhibition. Exhibition design is then an expanded field of information that can replicate an existing layout or reproduce one that will stay a virtual environment. In other words, “the challenge is to develop exhibition practices that provide appropriate contexts and experiences for art and design that emphasize multi-sensorial experience, the ‘activity in context’, over product” (Mattern, 2014, p. 136).

2.2 Digital museum experience

Trials with interactive platforms have been extending the museum experience beyond the physical visit. According to Vermeeren, Calvi, & Sabiescu (2018, p. 2), the design of such a complex experience unfolds in the following directions:

- dialogical engagement of the public;
- diversifying and broadening audiences, including the nameless 'crowd';
- the use of novel technologies, such as the Internet of Things (IoT) and Do-It-Yourself (DIY) technology;
- designing for museum systems and institutional ecosystems, rather than for individual museums only.

The concept of the museum experience is the turning point of a historical shift, as it implies a focus on the visitor and connections between visitor and objects rather than a focus on collections. In the course of time, new types of museum experiences gradually emerged (Tallon & Walker, 2008; Vermeeren et al., 2018), starting to challenge in the first instance the space of museums. Museum design used to be based on spatial features, thus creating an environment for visitors and flexibility for different layouts. The idea of interaction introduced another agency, that of real-time adaptability of the exhibition system, that is able to feed, in turn, behavioral models for better results (Muñoz, 2016). In this way, a mutual reliance is activated having, on one end, a machine-learning scenario, while on the other, a strong educational value for virtual museum users (Daniela, 2020). The exchange takes place in common ground for sharing, with behavioral implications rather than a vision-centered relation.

Hence, the overall design of an architectural space and the features of that space are not the only relevant characteristic for an exhibition. Especially in a virtual museum, in fact, interaction is to be linked with a subjective realm that curators might want to explore. Although the virtual tour is generally laid out through a specific curatorial project, with a specific visiting path for instance, if the virtual museum is designed to interact properly with the visitor, multiple itineraries should be allowed. Alternatively, it should be given a range of options that would tailor the experience on the basis of time allocation, level of interest, and cultural diversity. The effectiveness of interactive exhibitions can be measured through factors such

as context, movement, attractiveness, activity, and demonstrations (Muñoz, 2016). The most successful cases maximize cognitive accessibility, obtaining high visitor satisfaction standards (Solima, 2017). All these new possibilities offered by digital media and technology change the museum spaces into hybrid and complex fields. Contents can be communicated with storytelling techniques, developing a linear sequence of episodes that help deliver information on the artifacts. Their background story unfolds in games with characters that stimulate emotion and imagination (Danks, Goodchild, Rodriguez Echavarria, Arnold, & Griffiths, 2017) and makes teenagers more involved with the museum experience (Cesário, 2019).

3. Methodology

3.1 Virtual tour

The typology of the virtual tour that we have tested for this study is one of the most diffused, developed by Matterport as a twin model of the museum and operated with a traditional online interface provided with hotspots on the ground and tags on the objects. The experience of the visit can be augmented with pop-up windows that may provide additional storytelling via descriptions, voiceovers, videos, and other content.

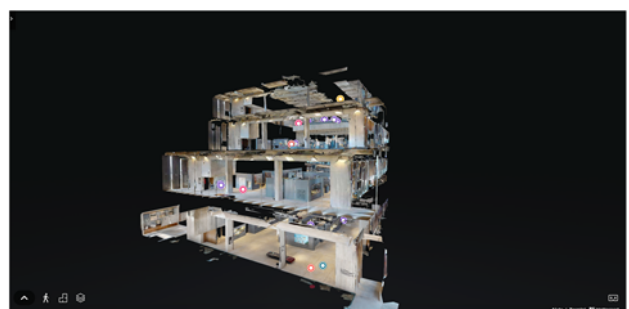


Fig. 2: 3D dollhouse view

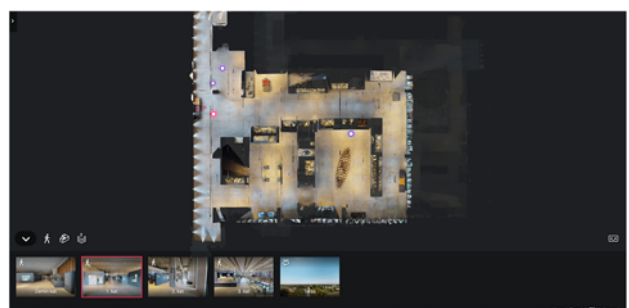


Fig. 3: Floor plan view

Kültür ve Turizm Bakanlığı, Turkey's Ministry of Culture and Tourism, opened a portal that has been collecting virtual tours of museums and archaeological sites in Turkey. At the moment, it consists of 33 cultural sites, ranging from Atatürk Museum in İzmir to Ephesus; Nemrut archaeological site in Adıyaman, the ruins of Assos in Çanakkale, the Istanbul Archaeological Museum, Hierapolis and Laodicea in Denizli, Uşak Museum, and others. By the end of 2020, virtual tours on the ministry portal have been visited 11.4 million times. The participants of the study have been tested on the online virtual tour of the Troya Müzesi (Troy Museum), an archaeological museum opened in 2018 and designed by Yalin Mimarlik in the area of Çanakkale, Turkey. The cubic Corten-clad building is 800m away from the archaeological site of Troy, which has been designated as a UNESCO World Heritage Site in 1998.

The museum's indoor area is approximately 12,700 square meters. It has around 2,000 artifacts on display, and more than 40,000 artifacts stored. The collection comprises "sculptures, sarcophaguses, inscriptions, altars, milestones, axes and cutters, terracotta potteries, metal vessels, gold pieces, weapons, coins, bone objects and tools, glass bracelets, ornaments, figurines, glass and terra cotta scent bottles, tear bottles, and other special pieces" (Erbil, 2018). The virtual tour consists of four exhibition floors plus one 360° panoramic view from the terrace. During the online virtual tour, visitors can explore the space in 3D, and switch to the floor plan when they need to continue with the exhibition. In the bottom left-hand corner, visitors have the option to activate a 3D dollhouse view that can be orbited (Fig. 2), and a planimetric view of the floor showing all highlighted hotspots (Fig. 3). It is also compatible with VR headsets.



Fig. 4: First floor of the museum



Fig. 5: Circle tags

The online virtual exhibition tour starts where the physical exhibition does. No introductory colophon has been provided in the welcome area but the virtual visitor can gather information from links to the official website. The twin model recreates in a virtual environment the same physical museum environment (Fig. 4). A number of white guiding circle tags on the ground are placed for visitors to follow along (Fig. 5), and different coloured circle tags can be clicked to access detailed descriptions of the artifacts (violet), web links (green), or move to another floor (red). Descriptions on exhibit labels and the curatorial statement are kept as it is in the physical exhibition (Fig. 6). During their visits, participants are required to calculate the duration of their online virtual tour by using a stopwatch and then report the duration to the researcher.

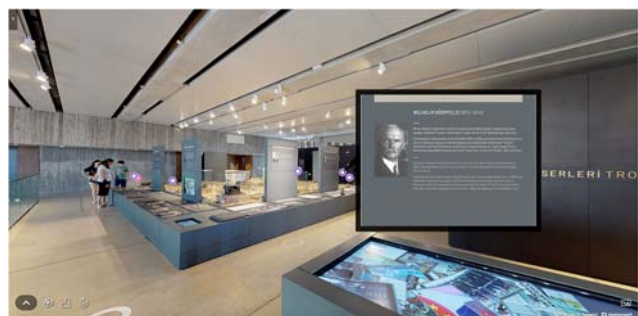


Fig. 6: pop-up with descriptions

3.2 Survey

Participants have been selected via the non-probability purposive sampling method. Eighty people form the sample group of experts under the condition that every participant is a student or practitioner in the field of art, architecture, or design; additionally, they have declared previous experiences with museums and/or exhibitions. Their age falls in the range of 20 to 35. With these

parameters, we have decided to maximize the required competencies in the field of exhibition and, at the same time, ideal practical knowledge of technology and experience with virtual environments. In other words, it matches the definition of digital natives given by Marc Prensky (2001) as individuals who manage to multitask, prefer visual information over text, and are familiar with gaming and networked information. The reason for this choice is linked to the virtual tour technology and the fact that participants will ideally explore the whole potential of the online application.

Additionally, the sample group that visited Troya Müzesi has been intentionally recruited on the basis of their place of residency. Half of the participants reside in Turkey, the other half in Italy. The first is expected to have some level of familiarity with Troy and the content of the museum, the second is expected to have the first visual impact with the museum via virtual tour. We will also verify if responses change on the basis of this geographic bias.

All participants have advanced knowledge of the English language because both the language of the study and that of the online exhibition tour is English. The last criterion was to balance equally male and female responding subjects.

The same interview, online virtual exhibition tour, and the survey are presented to the participant group without differences in terms of communication. Selected participants are informed about the content of the study by the researcher and are not compensated for their participation in this study.

4. Results

Results are based on one demographic questionnaire, one online interview, and one survey questionnaire to be submitted synchronously. The data were collected from 10 February to 10 March 2021 on the selected sample.

4.1 Demographic profile of respondents

Demographics is the first part of the instruments that have been employed for the study. The opening screen that participants have interacted with presents a set of questions on age, gender, profession, and nationality, in order to double-check the basic requirements to be part of the sample group. Age confirms the given range of

20-35 with a major concentration of 22-24 years old (38.5%), those who completed a Bachelor's degree and started a Master's degree; and another concentration of 28-30 years old (25.6%), which can be described as early-stage practitioners. Gender is 51.3% female, 47.4% male, the rest prefers not to say. Regarding their occupation, 33% are students, 26% work as architects, 12% work on interior architecture, and 10% are artists. With responses on nationality, we discovered that 86% have a nationality that coincides with their place of living. The rest are born in Iran, Albania, Serbia Montenegro, France, Bosnia and Herzegovina, Montenegro, Pakistan, and Iraq.

The second set of questions analyzes the relation of the sample group with computers and museums. The responses indicate that 78.2% spend five or more hours on the computer every day. This is due to the nature of freelance work for architects and distance learning for students during the lockdown. One-fifth of the experts visit museums every month, while almost half of the sample group visit museums every two months. Regarding virtual tours, 79.5% have had previous experience with online activities curated by museums, and 83.3% have already experienced virtual environments in general.

Results are consistent with the targeted profile that the study wanted to interrogate. Confidence with virtual environments and exhibition venue is confirmed.

4.2 Online interview

The online interview is composed of three open-ended questions. Visitors were also asked to record the duration of their tour and the number of floors they visited. Completion of the tour was not mandatory, as we wanted to see if attention and engagement dropped after a certain number of floors or the duration of the visit.

After peer examination of answers, we have created a map of responses (Fig. 7). The three columns represent administered questions, while rows represent individual answers. We have categorized each opinion ranging from "strongly negative" to "strongly positive".

The first question asks what visitors think about the application of digitization (such as interactive maps, audio guide, video guide, VR applications, AR applications, digital collections, etc.) in exhibition spaces and its relation to the architectural space. The majority (43%) showed a strongly positive attitude towards this scenario.

One representative response among the group is the following: “The application of digitization really enhances the exhibition experience. New technologies integrated with the architectural space not only make exhibitions more attractive and dynamic but also offer richer and more in-depth content. In particular, digital collections are a really important resource for museums. Museum storages are often closed to the public, disorganized, and forgotten. In my opinion, the digitization of collections and invisible storage heritage should be one the most important goals of a museum”. It shows an interesting possibility for museums to exhibit virtually those items that are usually stored in archives due to lack of space or differences with the main collection.

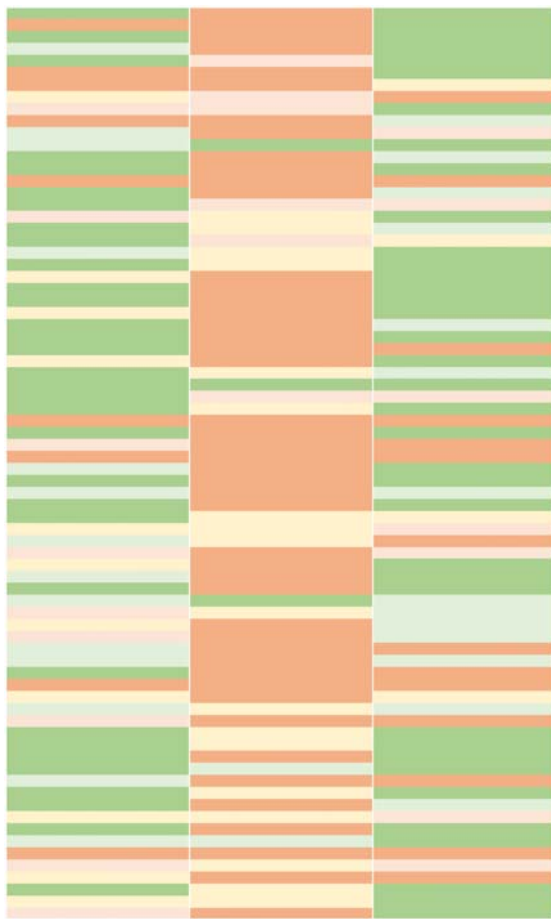


Fig. 7: Open-ended questions response map. Dark orange: strongly negative; light orange: negative; yellow: neutral; light green: positive; dark green: strongly positive.

One representative response among negative opinions (12%) observed that “interactive map, interface, and general digitization were well executed. However, I could not experience VR since I do not have the required hardware. It was

easy to navigate through and visually appealing. I have not experienced lags while moving around which is important for me. On the other hand, the tour was lacking in terms of details. It is hard to see small objects and their materials in detail and digital information cards were missing in some parts. It was hard reading what is written on the hanging posters or physical information cards”. This raises the issue of hardware performances as well as that of interpreting small details and objects. In general, recurring topics pointed out the fact that this specific VT was not interactive enough; that VT can be a useful preparatory tool before the visit, and after the visit too, to remind them what they saw. Others highlighted that VT is a great opportunity for the people who are interested in the collections in terms of accessibility. Finally, a group of respondents has appreciated the virtual twin of the museum but also expressed that the sensation of architectural space is lost.

The second set of questions enquired what visitors think about the contribution of virtual tours to the visitor experience in museums and whether they think VT can replace the physical visit. As shown in the response map, answers were mostly neutral (24%) or strongly negative (62%). One strongly negative answer focused on the atmospheric value of museums: “Although I think that technology is very important and gives added value to a museum experience, I don’t think that the physical visit can be replaced; the emotion of seeing the materiality of an object, its nuances, and details. I think the physical space of the museum is also difficult to replicate online at the moment: the smells, hearing the voices of other visitors, the natural light entering the room”. One negative response brought up the issue of Covid-19 restrictions saying, “In my opinion, they can’t replace a physical visit, but a virtual tour could be an important opportunity for everyone to reach culture and its expressions (during a pandemic, but also in normal times). Furthermore, it gives the possibility to spend all the time that a person needs to understand and appreciate the exhibition both for pleasure or for study”. One of the three strongly positive opinions confirmed that “virtual tours are important for accessibility. It may be difficult to visit museums physically especially in pandemic periods so virtual tours give chance to see collections all over the world”. Other recurring topics mentioned that the sense of museums as a place of enjoyment of culture and cultural identity

is not replaceable. Secondly, that it may be more successful to use digital tools in the physical museum instead of using them online. Finally, it has raised the fact that VT reduces environmental factors and funnels the visiting experience mostly through visual contact; it may cause the experience not to go beyond a certain level of the end-user feelings at that moment.

The third question asked how visitors feel about the migration of museums to online platforms (websites, virtual tours, web galleries, Instagram accounts, etc.) as new forms of communication. Positive (18%) and strongly positive (49%) opinions prevailed, though there were polarized negative or strongly negative responses and only 5% neutral. Some recorded that “the migration of museums to online platforms can represent the future and this could bring many people to the world of culture”. However, one of the strongly negative responses argued that at the moment, “museums have a limited audience, only a certain group of people visit museums and it is very little compared to the population. If museums are digitized, they will further lose their audience and eventually become impalpable”. Recurring topics showed agreement on the fact that migration to online platforms is positive for all museums or exhibition spaces, but mostly for small venues that are usually difficult to reach or have a limited budget for communication strategies. Secondly, visitors underlined the importance of museums as public spaces for social interaction. They argued that people are spending more and more time in their homes with a number of side effects. Museums can be one of the reasons for people to go out and communicate in person.

Tab. 1: Visit duration

Interval (min)	Visitors
0-10	11%
11-20	48%
21-30	23%
31-40	7%
41-50	2%
51-60	7%
61-75	3%

Tab. 2: Number of visited floors

Visited floors (nr)	Visitors
1	6%
2	6%

3	14%
4	9%
5	66%

Regarding visit duration, most of the visitors spent 10 to 30 minutes experiencing the VT. This data clearly shows that only the 9% spent more than 50 minutes navigating the virtual twin of Troy Museum (Tab.1). This study is not focused on assessing the intrinsic quality of VT, so we left open the possibility to interrupt the visit at any point, which produces a better index regarding engagement. We have recorded that two third of visitors visited all floors and the additional 360° panoramic view from the terrace (Tab. 2).

4.3 Survey questionnaire

In order to study the engagement of the virtual tour in an archaeological museum, we have defined a framework composed of two main constructs on the sense of presence: efficacy of spatial representation (ESP) and efficacy of artifact representation (EAR). And two other usage-based constructs: ease of use (EOU) and engagement (ENG). Hence, this framework is structured around EOU and how this factor is in turn related to the perceived quality of representations in a virtual tour and finally to visitor’s engagement. The EOU factor has been extensively studied in literature as a part of the Technology Acceptance Model (TAM) developed by Davis (1989) to assess people’s decision to use a certain technology (Marangunić & Granić, 2014). As applications of virtual reality are being increasingly implemented in the cultural sector, so are studies on its EOU (Che Mohd Yusoff, Azlina, & Halimah Badioze, 2011; El-Said & Aziz, 2021; Errichiello, Micera, Atzeni, & Del Chiappa, 2019; Hammady et al., 2020; Schiopu, Hornoiu, Padurean, & Nica, 2021). Secondly, EOU has been proved a predictor of user’s intention to adopt a technology (Davis, Bagozzi, & Warshaw, 1989; Huang, Backman, Backman, & Moore, 2013). In our framework, we have outlined the quality of visitor’s experience as Engagement (ENG), which enquires on involvement (Schubert, Friedmann, & Regenbrecht, 2001) and future use in learning scenarios (Dalgarno & Lee, 2010). In a broader sense, it has been defined as “the willingness to have emotions, affect and thoughts directed towards and aroused by the mediated activity in order to achieve a specific objective” (Bouvier, Lavoué, & Sehaba, 2014, p. 496). Finally, ESP and

EAR have been introduced to assess the visual quality of the virtual tour in relation to the main components of a museum visit: the architectural space and the exhibition itself. Both fall under the notion of perceived authenticity posing the issue of the role of the virtual as a possible substitute or complement of the physical experience (Evrard & Krebs, 2018; Jin, Xiao, & Shen, 2020). At the end, we will check if any correlation exists between these factors. One additional set of three questions checks incompleteness (IN) of the virtual experience asking agreement on negative evaluations. We have decided to include a dissatisfaction indicator (IN) to see if negative responses on virtual exhibition prevail but correlation will be measured only on ESP, EAR, EOU, and ENG.

All items measured employ a five-point rating scale from “strongly disagree” to “strongly agree”. All constructs are made of three items.

The reliability of the test has been measured with the Cronbach’s alpha model across the four main constructs (Tab. 3). Efficacy of spatial representation and that of the artifacts resulted in values of 0.77 and 0.83. Ease of use recorded 0.72 while engagement recorded 0.74.

Tab. 3: Reliability

Constructs	Cronbach’s alpha
Efficacy of spatial representation (ESP)	0.766
Efficacy of artifacts representation (EAR)	0.827
Ease of use (EOU)	0.719
Engagement (ENG)	0.744

Efficacy of spatial representation (Tab. 4) has been introduced to assess the quality of architectural representation of the museum in the virtual environment. The highest score has been given to the accuracy of spatial representation with a mean of 2.91 and a spread distribution across responses. Exhibition representation recorded 2.4 while the feeling of being present in the exhibition showed the lowest overall rating among all constructs with a 2.06 and 39% of respondents that strongly disagreed.

Tab. 4: Efficacy of spatial representation (ESP) (1=Strongly Disagree to 5=Strongly Agree)

Measure	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
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Efficacy of artifact representation (Tab. 5) measured how qualitative properties of objects were perceived in the virtual tour. While materiality recorded a 3.25 with a similar number of neutral and disagreeing responses, perception of dimensions reached 3.16. Perception of colors was particularly appreciated with the highest mean score among constructs, 3.52, and the lowest standard deviation.

The construct on ease of use (Tab. 6) has been built to measure technical aspects of using the virtual tour. Accessibility of information on the exhibition within the online application showed agreement or neutral disposition by 65% of the sample. Easy navigation of the tour scored the highest mean of the construct with 3.38. A total of 53.3% disagreed or strongly disagreed that the tour provided the feeling of a customized visiting experience. Negative aspects were explored with a set of questions on incompleteness (Tab. 7). Almost 52% strongly agreed that more multimedia content is needed. Other virtual tours provide, for instance, pop-up windows with videos and voice-overs, or build storytelling support that follows the visit. The problem of focusing too much on the interactivity of the application rather than its content has been another issue encountered by a relevant part of the sample with a mean of 3.4. Despite a load of visual material, internet connections have not created difficulties with a mean of 1.53 and a low standard deviation of 0.912.

Engagement (Tab. 8) is the construct that we built as the main target to measure the efficacy of the virtual tour. The engagement with the story of Troy showed a mean of 2.56, and one-third of respondents declared to be neutral on this issue. The question on the willingness to look for other virtual tours in the near future, which might be an indication of the long-term engagement, recorded a mean of 2.92 though having a dispersed response. The sample was able to focus on the tour without distractions with a positive mean of 3.14.

In terms of the overall assessment, the efficacy of artifacts representation (EAR) recorded the highest mean value of 3.09 among constructs, while the efficacy of spatial representation (ESP) the lowest, 2.46 (Tab. 9).

Q4 Convincing virtual representation of space	11.7%	27.3%	20.8%	20.8%	19.5%	2.91	1.320
Q5 Convincing virtual representation of exhibition	6.5%	13%	20.8%	33.8%	26%	2.40	1.195
Q10 I could feel my presence in virtual tour	2.6%	10.4%	16.9%	31.2%	39%	2.06	1.104

Tab. 5: Efficacy of artifact representation (EAR) (1=Strongly Disagree to 5=Strongly Agree)

Measure	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Q6 I could perceive the materiality of artifacts	5.2%	18.2%	27.3%	29.9%	19.5%	2.60	1.150
Q7 I could perceive the dimension of artifacts	15.6%	24.7%	28.6%	22.1%	9.1%	3.16	1.204
Q8 I could perceive the color of artifacts	14.3%	44.4%	23.4%	15.6%	2.6%	3.52	1.008

Tab. 6: Ease of use (EOU) (1=Strongly Disagree to 5=Strongly Agree)

Measure	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Q1 Accessible information on exhibition	9.1%	36.4%	28.6%	22.1%	3.9%	3.25	1.028
Q2 Easy navigation of the VT	19.5%	31.2%	20.8%	24.7%	3.9%	3.38	1.170
Q9 Customized tour in virtual venue	3.9%	20.8%	22.1%	28.6%	24.7%	2.51	1.188

Tab. 7: Incompleteness (IN) (1=Strongly Disagree to 5=Strongly Agree)

Measure	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Q3 Need of more multimedia contents	51.9%	26%	16.9%	5.2%	0%	4.25	0.920

Q14 I focused too much on interactivity	15.6%	35.1%	26%	20.8%	2.6%	3.40	1.067
Q15 Internet connection interfered with VT	1.3%	3.9%	9.1%	18.2%	67.5%	1.53	0.912

Tab. 8: Engagement (ENG) (1=Strongly Disagree to 5=Strongly Agree)

Measure	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Q11 I could easily engage with the history of Troy	1.3%	19.5%	33.8%	24.7%	20.8%	2.56	1.070
Q12 I will look for more virtual experiences	15.6%	20.8%	24.7%	18.2%	20.8%	2.92	1.365
Q13 I could focus on the virtual tour without distractions	16.9%	29.9%	18.2%	20.8%	14.3%	3.14	1.325

Tab. 9: Means and Standard Deviations of Variables

Variables	Mean	Standard Deviation
Efficacy of spatial representation (ESP)	2.46	1.206
Efficacy of artifacts representation (EAR)	3.09	1.121
Ease of use (EOU)	3.05	1.129
Incompleteness (IN)	3.06	0.966
Engagement (ENG)	2.87	1.253

4.4 Regression analysis

As the intention is to study the correlation between the constructs and the engagement of virtual tour, we propose the following research model (Fig. 8):

- H1: Efficacy of spatial representation (ESP) will positively affect engagement (ENG).
- H2: Ease of use (EOU) will positively affect engagement (ENG).
- H3: Efficacy of artifacts representation (EAR) will positively affect engagement (ENG).
- H4: Ease of use (EOU) will positively affect the efficacy of spatial representation (ESP).
- H5: Ease of use (EOU) will positively affect the efficacy of artifacts representation (EAR).

Hypotheses relating authenticity factors (ESP + EAR in our case) to IT use in Museum context have been already advanced by Pallud & Straub (2007), as authenticity is strictly related to perceived substitutability of VR, then to its implementation (Schiopu et al., 2021). Quality of viewing condition and engagement is correlated by Wagler & Hanus (2018). Authenticity and engagement bond has been hypothesized and studied by Kim, Lee, & Jung (2018). In Dalgarno & Lee (2010)'s model, representation fidelity in 3D virtual environments influences engagement, as one possible learning benefit. The hypothesis that ease of use affects engagement is discussed by Hammady et al. (2020), Heerink, Kröse, Wielinga, & Evers (2008), and Sun & Zhang (2006).

Tab. 8: Correlation between constructs

Hypotheses	Relationship	Correlation coefficient (r)	R square
H1	ESP -> ENG	0.696	0.484
H2	EOU -> ENG	0.512	0.262
H3	EAR -> ENG	0.684	0.467
H4	EOU -> ESP	0.508	0.258
H5	EOU -> EAR	0.592	0.351

In order to verify these relationships, we run a regression analysis (Tab. 8). All ρ -values (ρ) are less than 0.05 so the regression model is statistically significant. The table shows a positive correlation between hypothesized relationships. Correlation is particularly significant between spatial representation and engagement (0.70), artifacts representation, and engagement (0.68) with an R^2 of 0.48 and 0.47. Hypothesis H2 and H4 show a similar correlation of 0.51. All cross-analyzed pairs of relationships resulted in significant relationships.

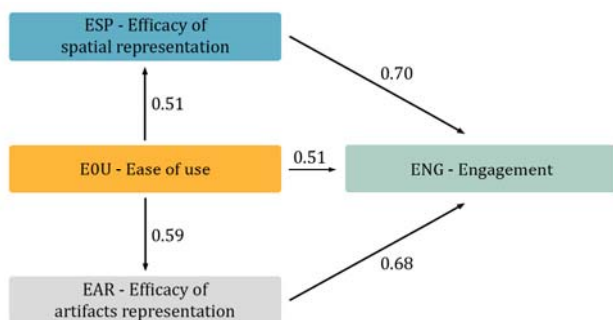


Fig. 8: Model with correlation coefficients

4.5 Country-wise evaluations

The sample group has been built by splitting half participants on the basis of their country of residency, Turkey or Italy. Turkey-based visitors are expected to have more confidence with Troya Müzesi. In the online interview, part of the Turkish respondents declared that they had previously visited the museum. In general, Italy-based visitors showed a more polarized response, contributing more to the strongly positive opinion on the first and third question of the interview; respectively 60% and 64% of strongly positive were Italians. As the second question gathered most of the strongly negative opinions, Italians contributed with 56%.

In order to check differences between the two groups on the four constructs, we run independent-samples T-test. We recorded that ρ -values (ρ) are all above the threshold of 0.05, meaning that there is no statistically significant difference between subjects living in Italy or Turkey.

5. Conclusions

4.1 Interview and survey

This study focuses on the level of engagement of virtual tours in museums looking at representation of architectural space, representation artifacts, and ease of use, as possible correlated factors. A sample group of eighty young experts in the field of art, architecture, or design assessed their virtual visit at the Troya Müzesi exhibition. Demographics were coherent with the scope of the research. The online interview showed opinions on how virtual tours can be used to complement information before and after the visit, then interpreting the online application as an addendum to the physical visit. Environmental features of museums are regarded as a unique aspect that cannot be replaced with an immersive environment, at least via the technology that we have been experimenting with. Another hint is that duration of a virtual tour is not comparable with that of a physical exhibition. The sample group had a positive opinion towards the development of digitization of museums and the widening of communication outlets. However, they were skeptical about the interchangeability of virtual visits. The survey questionnaire evidenced the need to enrich the current technology of virtual tours with additional multimedia content. Material features of the artifacts were generally appreciated, while the representation of space scored a lower value. The online application was considered generally easy to use. These three constructs demonstrated a correlation with user engagement: improvements on the quality of representation and on immersive features will result in an increased engagement. It is understood that the peculiar design of such interactive platforms is decisive for the improvement of the quality of the virtual visit. Their improvement will advance in parallel with that of the digital technologies on which they are based.

4.2 Limitations and future directions

This study has some limitations. The specified sample is defined with the aforementioned criteria to get an expert opinion on virtual tours for museums. The responses will be considered as representative of the wider population only after a large-scale interview with random samples. Second, the study was conducted on a specific virtual tour of the Troy Museum. Different virtual tours and different kinds of reproduced artifacts may vary in perception responses. We have purposely analyzed one museum with archaeological findings since we were interested in the representation of 3D objects. Collections or exhibitions with paintings and photographs can have a different interface architecture because of their intrinsic planarity.

Another issue is related to this specific situation of Covid-19 restrictions, which has accelerated many digitization processes as already mentioned in the first paragraph of the paper. Another large-scale study on the use of virtual tours, when physical exhibitions will be open, can predict visitor's engagement within an ordinary operational regime.

Finally, the quality of the virtual tour itself can vary from case to case and be enriched with

multimedia content. Our sample strongly agreed on the fact that a lack of additional audio, video, games, and others, is an important drawback in the selected virtual tour. Future lines of research should tackle how museums keep implementing virtual tours under normal circumstances. Further studies on visitor engagement will help developers design more immersive and informative platforms. Another issue to be explored is the integration with storytelling techniques and the creation of a plot made of scenes or chapters. This is expected to extend the field of disciplines to communication and game design. New outlets of dissemination of cultural heritage are widening museums' possibilities for visitor engagement, possibly requiring specialist curators of a parallel virtual venue.

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REFERENCES

- Argyriou, L., Economou, D., & Bouki, V. (2020). Design methodology for 360° immersive video applications: the case study of a cultural heritage virtual tour. *Personal and Ubiquitous Computing*, 24(6), 843-859. doi:<https://doi.org/10.1007/s00779-020-01373-8>
- Barbieri, L., Bruno, F., & Muzzupappa, M. (2017). Virtual museum system evaluation through user studies. *Journal of Cultural Heritage*, 26, 101-108. doi:<https://doi.org/10.1016/j.culher.2017.02.005>
- Bonacini, E. (2015). A pilot project with Google indoor Street View: a 360° tour of "Paolo Orsi" museum (Syracuse, Italy). *SCientific RESearch and Information Technology*, 5(2), 151-168. doi:<https://doi.org/10.2423/i22394303v5n2p151>
- Bouvier, P., Lavoué, E., & Sehaba, K. (2014). Defining Engagement and Characterizing Engaged-Behaviors in Digital Gaming. *Simulation & Gaming*, 45(4-5), 491-507. doi:<https://doi.org/10.1177/1046878114553571>
- Cesário, V. (2019). *Guidelines for combining storytelling and gamification: which features would teenagers desire to have a more enjoyable museum experience?* Paper presented at the Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland Uk. <https://doi.org/10.1145/3290607.3308462>
- Che Mohd Yusoff, R., Azlina, A., & Halimah Badioze, Z. (2011). Evaluation of user acceptance of mixed reality technology. *Australasian Journal of Educational Technology*, 27(8), 1369-1387. doi:<https://doi.org/10.14742/ajet.899>
- Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, 41(1), 10-32. doi:<https://doi.org/10.1111/j.1467-8535.2009.01038.x>
- Daniela, L. (2020). Virtual museums as learning agents. *Sustainability*, 12(7), 1-24.
- Danks, M., Goodchild, M., Rodriguez Echavarria, K., Arnold, D., & Griffiths, R. (2017, 11-13 June). *Interactive storytelling and gaming environments for museums: the interactive storytelling exhibition project*. Paper presented at the Technologies for E-learning and Digital Entertainment: Second International Conference, Edutainment 2007, Hong Kong, China.
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), 319-340. doi:<https://doi.org/10.2307/249008>
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, 35(8), 982-1003. doi:<https://doi.org/10.1287/mnsc.35.8.982>
- El-Said, O., & Aziz, H. (2021). Virtual Tours a Means to an End: An Analysis of Virtual Tours' Role in Tourism Recovery Post COVID-19. *Journal of Travel Research*, 1-21. doi:<https://doi.org/10.1177/0047287521997567>
- Erbil, Ö. (2018). Çanakkale villagers rush to newly opened Troy Museum. *Hürriyet Daily News*. Retrieved from <https://www.hurriyetdailynews.com/canakkale-villagers-rush-to-newly-opened-troy-museum-138025>
- Errichiello, L., Micera, R., Atzeni, M., & Del Chiappa, G. (2019). Exploring the implications of wearable virtual reality technology for museum visitors' experience: A cluster analysis. *International Journal of Tourism Research*, 21(5), 590-605. doi:<https://doi.org/10.1002/jtr.2283>

- Evrard, Y., & Krebs, A. (2018). The authenticity of the museum experience in the digital age: the case of the Louvre. *Journal of Cultural Economics*, 42(3), 353-363. doi:<https://doi.org/10.1007/s10824-017-9309-x>
- Feng, X. (2020). Curating and Exhibiting for the Pandemic: Participatory Virtual Art Practices During the COVID-19 Outbreak in China. *Social Media + Society*, 6(3), 1-6. doi:<https://doi.org/10.1177/2056305120948232>
- Hammady, R., Ma, M., & Strathearn, C. (2020). Ambient information visualisation and visitors' technology acceptance of mixed reality in museums. *Journal on Computing and Cultural Heritage (JOCCH)*, 13(2), 1-22. doi:<https://doi.org/10.1145/3359590>
- Hammady, R., Ma, M., & Temple, N. (2016). *Augmented Reality and Gamification in Heritage Museums*. Paper presented at the Second Joint International Conference on Serious Games, JCSG 2016, Brisbane, QLD, Australia.
- Heerink, M., Kröse, B., Wielinga, B., & Evers, V. (2008). *Enjoyment intention to use and actual use of a conversational robot by elderly people*. Paper presented at the Proceedings of the 3rd ACM/IEEE international conference on Human robot interaction, Amsterdam, The Netherlands.
- Huang, Y.-C., Backman, S. J., Backman, K. F., & Moore, D. (2013). Exploring user acceptance of 3D virtual worlds in travel and tourism marketing. *Tourism Management*, 36, 490-501. doi:<https://doi.org/10.1016/j.tourman.2012.09.009>
- Huhtamo, E. (2010). On the Origins of the Virtual Museum. In R. Parry (Ed.), *Museums in a digital age* (pp. 121-135). London-New York: Routledge.
- Jin, L., Xiao, H., & Shen, H. (2020). Experiential authenticity in heritage museums. *Journal of Destination Marketing & Management*, 18, 1-11. doi:<https://doi.org/10.1016/j.jdmm.2020.100493>
- Kabassi, K. (2017). Evaluating websites of museums: State of the art. *Journal of Cultural Heritage*, 24, 184-196. doi:<https://doi.org/10.1016/j.culher.2016.10.016>
- Kabassi, K., Amelio, A., Komianos, V., & Oikonomou, K. (2019). Evaluating Museum Virtual Tours: The Case Study of Italy. *Information*, 10(11), 1-11. doi:<https://doi.org/10.3390/info10110351>
- Karacan, E., & Resta, G. (2020). Virtual exhibition and visitor experience: how digital storytelling enhances online exhibition spaces. In Y. Aksoy & E. Duyan (Eds.), *Contemporary issues in architecture: Ecology, urban environment, experience* (pp. 135-154). Istanbul: DAKAM.
- Kim, M. J., Lee, C.-K., & Jung, T. (2018). Exploring Consumer Behavior in Virtual Reality Tourism Using an Extended Stimulus-Organism-Response Model. *Journal of Travel Research*, 59(1), 69-89. doi:<https://doi.org/10.1177/0047287518818915>
- Luo, S.-S., Shedd, B. A., & Nanetti, A. (2018). Enhancing the experience of the western Xia imperial tombs heritage site (PRC, Ningxia) through animated installations. *SCientific RESearch and Information Technology*, 8(1), 1-32. doi:<https://doi.org/10.2423/i22394303v8n1p1>
- Marangunić, N., & Granić, A. (2014). Technology acceptance model: a literature review from 1986 to 2013. *Universal Access in the Information Society*, 14(1), 81-95. doi:<https://doi.org/10.1007/s10209-014-0348-1>
- Mattern, S. (2014). Animated spaces. *The Senses and Society*, 9(2), 131-150. doi:<https://doi.org/10.2752/174589314X13953118734742>
- Muñoz, H. (2016, 17-22 July). *The interaction in an interactive exhibition as a Design-Aesthetics-Experience relationship*. Paper presented at the 18th International Conference, HCI International, Toronto, Canada.

- Network of European Museum Organisations - NEMO. (2020). *Survey on the impact of the COVID-19 situation on museums in Europe. Final Report*. Retrieved from https://www.nemo.org/fileadmin/Dateien/public/NEMO_documents/NEMO_COVID19_Report_12.05.2020.pdf
- Network of European Museum Organisations - NEMO. (2021). *Follow-up survey on the impact of the COVID-19 pandemic on museums in Europe. Final Report*. Retrieved from https://www.nemo.org/fileadmin/Dateien/public/NEMO_documents/NEMO_COVID19_FollowUpReport_11.1.2021.pdf
- Pallud, J., & Straub, D. W. (2007). *Real vs. Virtual: A Theoretical Framework for Assessing the Role of Authenticity in Visitor Interactions with Museum Technologies*. Paper presented at the Americas Conference on Information Systems (AMCIS), Keystone, Colorado, USA.
- Povroznic, N. (2018, 7-9 March). *Virtual museums and cultural heritage: Challenges and solutions*. Paper presented at the Digital Humanities in the Nordic Countries 3rd Conference, Helsinki, Finland.
- Povroznic, N. (2020, 21-23 October). *Digital History of Virtual Museums: The Transition from Analog to Internet Environment*. Paper presented at the Digital Humanities in the Nordic Countries 5th Conference, Riga, Latvia.
- Prensky, M. (2001). Digital Natives, Digital Immigrants Part 1. *On the Horizon*, 9(5), 1-6. doi:<https://doi.org/10.1108/10748120110424816>
- Schiopu, A. F., Hornoiu, R. I., Padurean, M. A., & Nica, A.-M. (2021). Virus tinged? Exploring the facets of virtual reality use in tourism as a result of the COVID-19 pandemic. *Telematics and Informatics*, 60, 1-20. doi:<https://doi.org/10.1016/j.tele.2021.101575>
- Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The Experience of Presence: Factor Analytic Insights. *Presence: Teleoperators and Virtual Environments*, 10(3), 266-281. doi:<https://doi.org/10.1162/105474601300343603>
- Solima, L. (2017). Museums, accessibility and audience development. In M. Cerquetti (Ed.), *Bridging theories, strategies and practices in valuing cultural heritage* (pp. 225-240). Macerata: eum edizioni università di Macerata.
- Sun, H., & Zhang, P. (2006). Causal Relationships between Perceived Enjoyment and Perceived Ease of Use: An Alternative Approach. *Journal of the Association for Information Systems*, 7(9), 618-645. doi:<https://doi.org/10.17705/1jais.00100>
- Tallon, L. c., & Walker, K. (Eds.). (2008). *Digital technologies and the museum experience: handheld guides and other media*. Plymouth: AltaMira Press.
- Vermeeren, A. P. O. S., Calvi, L., & Sabiescu, A. (Eds.). (2018). *Future museum experience design: Crowds, ecosystems and novel technologies*. Cham: Springer.
- Wagler, A., & Hanus, M. D. (2018). Comparing Virtual Reality Tourism to Real-Life Experience: Effects of Presence and Engagement on Attitude and Enjoyment. *Communication Research Reports*, 35(5), 456-464. doi:<https://doi.org/10.1080/08824096.2018.1525350>