SCIRES it
SCIentific RESearch and Information Technology
*Ricerca Scientifica e Tecnologie dell'Informazione*
Vol 11, Issue 1 (2021), 151-166
e-ISSN 2239-4303, DOI 10.2423/i22394303v11n1p151

CASPUR-CIBER Publishing, http://www.sciresit.it

# 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).

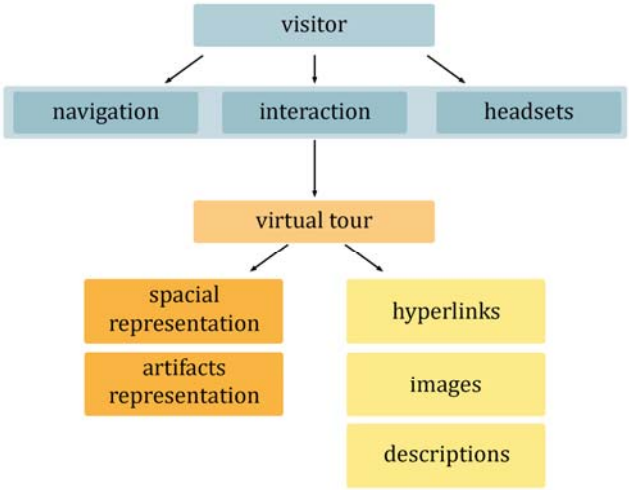


**Fig. 1:** Virtual tour museum framework

## 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.

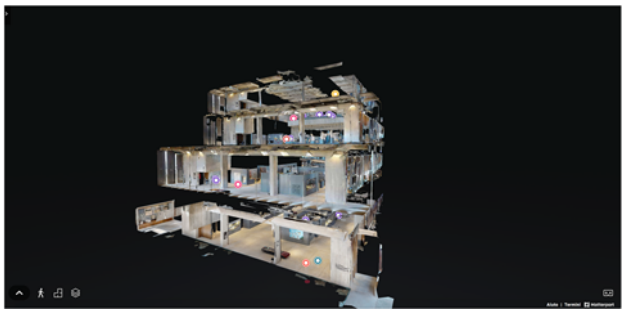

**Fig. 2:** 3D dollhouse view

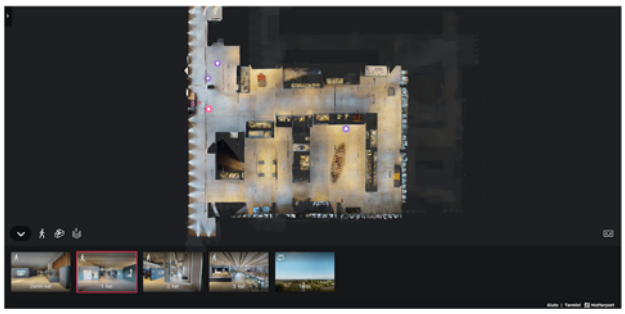

**Fig. 3:** Floor plan view

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 Izmir 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 re-creates 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.

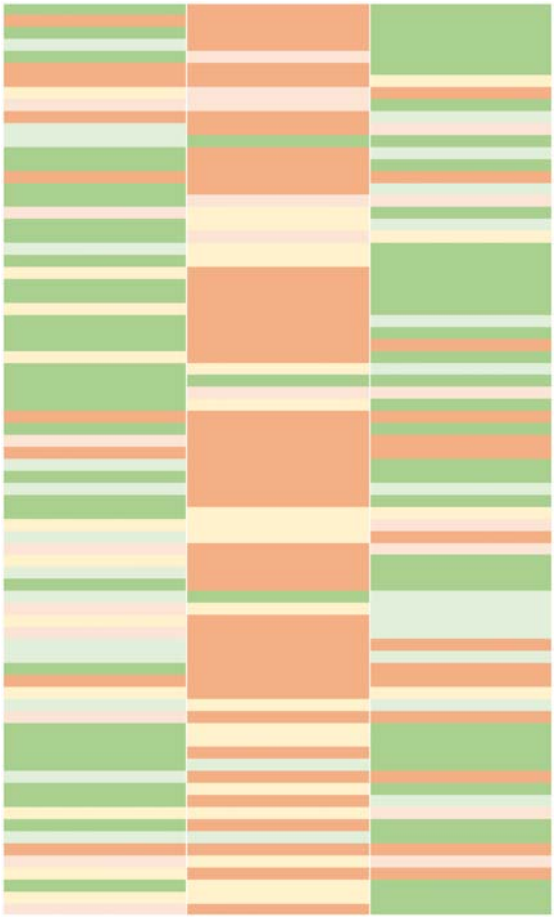

**Fig. 7:** Open-ended questions response map. Dark orange: strongly negative; light orange: negative; yellow: neutral; light green: positive; dark green: strongly positive.

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.

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).

**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 |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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.

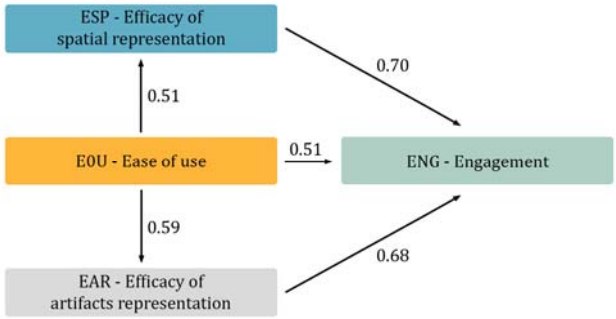


**Fig. 8:** Model with correlation coefficients

### *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.

## *6. Acknowledgements*

The authors conducted the research presented in this paper between January 2021 and April 2021. The research team is grateful to all early-career professionals who participated in the survey. Their personal data has been anonymized with a unique ID number. Each participant's answers are confidential and have been processed using the ID number. Their data will not be shared.

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.ne-mo.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.ne-mo.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.

Povroznik, 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.

Povroznik, 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