yedi
SANAT, TASARIM VE BİLİM DERGİSİ
JOURNAL OF ART, DESIGN & SCIENCE

Araştırma Makalesi
Research Article

SANATTA DİJİTALİZM ÖZEL SAYISI 2024
DIGITALISM IN ART SPECIAL ISSUE 2024

DEÜ GSF

Ergin, G. (2024). Bridging the gap: Using digital interactives for social museums. yedi: Journal of Art, Design and Science, Digitalism in Art Special Issue, 129-141. doi: 10.17484/yedi.1494586

Bridging the Gap: Using Digital Interactives for Social Museums

Uçurumu Kapatmak: Sosyal Müzeler için Dijital İnteraktiflerin Kullanılması

Gamze Ergin, *Interior Architecture Department, Mimar Sinan Fine Arts University, 0000-0002-7874-4902*

Abstract

Designing the built environment with an inclusive approach that allows equal access for everyone is necessary to reduce social inequalities. Creating a physical environment that includes all segments of society and activates all senses is crucial in museum spaces. Digital interactions used in museum spaces offer new possibilities and interfaces to eliminate inequalities and increase inclusiveness. This study examines the integration of digital interactives in museums with a focus on the social museum concept. Through a comprehensive review of literature spanning museum studies on social museums, digital interactives, and inclusive museum concepts, this research investigates the role of digital interactives in fostering social engagement and facilitating interactive learning experiences within museum settings. Drawing on the theoretical framework and practical examples the paper explores how to employ digital technologies strategically to enhance visitor interaction, promote inclusivity, and facilitate knowledge sharing in social museum environments. This research demonstrates the transformative potential of digital interactives in museums as social spaces and provides a comprehensive understanding of the dynamic relationship between technology, museum practices, and social inclusion. The result of the research shows that digital interactives used in museum environments, such as haptic tools, wearables and mobile technologies, extended reality technologies, RFID and AI technologies, offer new ways of engagement for a more social museum and increase social inclusion.

Keywords: Inclusive design, social museums, universal design, digital assistive tools, information communication technologies, digital interactives, social inclusion.

Academical Disciplines/Fields: Interior design, museum studies, information communication technologies.

Özet

Yapılı çevrenin herkese eşit erişim imkânı tanıyan kapsayıcı bir yaklaşımla tasarlanması toplumsal eşitsizliklerin azaltılması açısından gereklidir. Müze mekânlarında toplumun tüm kesimlerini içine alan ve tüm duyuları harekete geçiren bir fiziksel çevre yaratmak önemlidir. Müzelerde kullanılan dijital etkileşimler, eşitsizlikleri ortadan kaldırmak ve kapsayıcılığı artırmak için yeni imkânlar ve ara yüzler sunmaktadır. Çalışmada sosyal müze kavramına odaklanarak dijital etkileşimli teknolojilerin müzelere entegrasyonu incelenmekte ve sosyal müzeler, dijital etkileşimli araçlar ve kapsayıcı müze kavramı üzerine müze çalışmalarını kapsayan kapsamlı bir literatür taraması yoluyla, dijital etkileşimli araçların sosyal katılımı teşvik etmedeki ve müze ortamlarında etkileşimli öğrenme deneyimlerini kolaylaştırmadaki rolü araştırılmaktadır. Teorik çerçeveden ve pratik örneklerden yola çıkan bu çalışma, ziyaretçi etkileşimini artırmak, kapsayıcılığı teşvik etmek ve sosyal müzecilik bağlamında bilgi paylaşımını kolaylaştırmak için dijital teknolojilerin stratejik olarak nasıl kullanılabileceğini incelemektedir. Araştırmada birer sosyal alan olarak müzelerde dijital etkileşimlerin dönüştürücü potansiyeli ortaya konulmakta; dijitalleşme, müze uygulamaları ve sosyal kapsayıcılık arasındaki dinamik ilişkinin kapsamlı bir şekilde anlaşılması hedeflenmektedir. Araştırma sonucunda, müzelerde kullanılan dokunsal araçlar, giyilebilir ve mobil teknolojiler, genişletilmiş gerçeklik teknolojileri, radyo frekansı ile tanımlama ve yapay zekâ teknolojileri gibi dijital etkileşimlerin, daha sosyal bir müze için yeni katılım yolları sunduğu ve sosyal kapsayıcılığı artırdığı görülmektedir.

Anahtar Sözcükler: Kapsayıcı tasarım, sosyal müzeler, evrensel tasarım, dijital yardımcı araçlar, bilgi iletişim teknolojileri, dijital etkileşimler, sosyal kapsayıcılık.

Akademik Disiplin(ler)/Alan(lar): İç mimari tasarım, müzecilik, bilgi iletişim teknolojileri.

- **Corresponding Author:** Gamze Ergin, Interior Architecture Department, Mimar Sinan Fine Arts University.
- **Adress:** Mimar Sinan Fine Arts University, Pürtelaş Hasan Efendi Mahallesi, Meclisi Mebusan No:24, 34427 Beyoğlu/Istanbul.
- **E-mail:** gamze.ergin@msgsu.edu.tr
- **Published Online:** 23.09.2024 **Date of Arrival:** 02.06.2024 **/ Date of Admission:** 29.08.2024
- **doi:** 10.17484/yedi.1494586

1. Introduction

Museums boast a dynamic structure. Inclusive relationships between museums and the public ensure sustainability and reflect this dynamism. Contemporary museums are centers that contribute to society in many ways. Apart from their traditional roles of preserving and developing collections, they are becoming increasingly socialized structures emphasizing their educational aspects. Historically, museums have primarily focused on the intellectual aspects of their physical spaces, such as the physical arrangement of exhibits and layouts designing order to create appealing offerings and attract visitors through efficient marketing. Nonetheless, in recent times, the significance of emotional and sensory characteristics in enhancing the museum experience is gaining more attention (Cerdan Chiscano & Jiménez-Zarco, 2021).

As public spaces, contemporary museums aim an environment that engage all members of society and all senses. Inclusive design is a design approach that ensures equal access for everyone, incorporates accessibility standards into the design process, prioritizes social equality, and supports social interaction. Accessibility is the heart of inclusive design. Regardless of age, gender, or physical and mental abilities, everyone should have the opportunity to participate in social activities and have equal access to public spaces. Therefore, adressing issues of access, equality, and diversity to museum content,

According to United Nations Development Programme (UNDP), inclusive digital transformation is crucial for achieving inclusivity. An inclusive digital transformation aims to ensure that digital technologies are easily accessible and used safely and meaningfully by all individuals (United Nations Development Programme, 2023, p. 4). Enhancing museum accessibility is also vital for sustainability. ICOM's theme for International Museum Day 2023 'Sustainability and Wellbeing' highlights the professional relationship between communities and museums (Güneröz, 2023). In this context, as in other industries, businesses, and institutions, the use of digital interactive tools to increase inclusivity in museum practices is becoming more widespread.

Museums provide education and exposure to specific subjects or items in various formats. While technology allows for new ways of viewing and comprehending collections, it also alters the presentation of those collections. Current digital technologies provide opportunities to create tools that can shape the space, regardless of the content form. In its Digital Strategy 2022-2025 report, UNDP defines digital as:

> An ever-evolving range of technologies (like mobile technologies, artificial intelligence, machine learning, blockchain, Internet of Things (IoT) and robotics to name a few) that impact all aspects of our world. A mindset, which translates into a new way of working that enables people and institutions to innovate with technology (United Nations Development Programme, 2022, p. 5).

As technology has expanded the diversity of artistic production, museums must leverage it as a tool to enhance their operations and exhibitions. These new technologies are resources for helping museums realize their objectives of preserving artwork and displaying it to the public.

With advancements in digital interactive tools and exhibition techniques, museum spaces are becoming more accessible and inclusive. Based on this hypothesis, this research examines the integration of digital interactions into museums, focusing on the concept of social museums. Secondary data was collected through a literature review on the concepts of social museums, digital interactives, and inclusive museums. The research also draws on data collected from current museum and technology news, museum websites and other online sources related to digital cultural development.

The paper explores the role of digital interactives in promoting social engagement and facilitating interactive experiences in museum environments. Drawing on the theoretical framework and practical examples, the research explores how digital technologies can be used strategically to enhance visitor engagement, promote inclusivity, and facilitate knowledge sharing in social museum environments.

2. Understanding the Social Museum: Social Inclusion, Equality and Diversity

According to the International Council of Museums (ICOM), there are two types of museums that apply the concept of inclusiveness at different scales: community museums and social museums. Community museums are part of the social museum movement, and their sustainability depends on the social, cultural, professional, and geographical groups they represent. While they are usually professionally managed, they can also operate solely with the support of local initiatives. The subjects they address are directly related to

the functioning and identity of their audience. Community museums are seen as broader and more interdisciplinary than social museums, encompassing them. On the other hand, social museums are institutions that aim to analyze the evolution of humanity in its social and historical components, conveying milestones, and understanding the diversity of cultures and societies (Barroso & Vaillant, 1993). This interdisciplinary field produces exhibitions on topics such as food crises, migration, and ecology that affect societies worldwide. Both types of museums aim to be inclusive to their audiences, but the social museum is seen as the type that most comprehensively reflects the multinational, sensitive, cultural, and educational center quality.

In the field of museum studies, equality and diversity have been significant topics for a long time (Sandell, 2011, p. 138). In the 1990s, the UK government's social inclusion policy agenda promoted the idea of inclusion in museums. In the United States, museums began to evaluate the concept at the beginning of the 21st century. The notion was primarily associated with concepts like diversity, anti-racism, equality, neutrality, social justice, and multiculturalism (Coleman, 2018, p. 11).

The American Alliance of Museums (AAM) (2018) introduced the concept of inclusion in their *Diversity and Inclusion Policy*. The policy states that museums should embrace diversity and strive to make their programs and collections accessible to all audiences while opposing all forms of discrimination. Education is emphasized as a tool for creating an inclusive environment. In October 2022, AAM released guidelines emphasizing the importance of diversity, equity, accessibility, and inclusion (DEAI) practices in the museum field. These practices are crucial for the future health and endurance of museums and to effectively address the evolving needs of the public (American Alliance of Museums, 2022). In order to achieve this, museums have implemented a holistic approach for assuring diversity, equality and inclusion and started using strategies such as providing free entry, guided tours, free community programs, and shared spaces. For example, state museums in the UK are free to visit ensuring that people have access to cultural heritage and knowledge regardless of financial constraints.

It is important to remember that inclusion should be addressed in a wide range of contexts. In the literature, there are studies on increasing the participation of children with autism in museum activities (Cho & Jolley, 2016; Lurio, 2016), as well as studies stating that providing access opportunities alone is not enough to achieve adequate inclusion for children (Edelstein, 2022). The importance of including marginalized or disadvantaged individuals in the transformation process in museums is emphasized, as it provides important opportunities to make the process more participatory, and the significance of connecting, being creative, and trying new initiatives and programs is also emphasized.

3. Designing Social Museum Exhibitions

In museum spaces where experience, interaction and communication are at the forefront of knowledge transfer, exhibition design requires a participatory process that brings together multiple stakeholders. Historically, the three key elements of exhibition design have been gallery space (design), collection content (curation) and audience. These elements have evolved with the increasing interpretive role of museums and the development of a more unified design discipline. While space and content still play a pivotal role in shaping exhibitions, the influence of audience considerations, particularly user-centered design, has greatly increased in modern exhibition development (Miles et al., 1988, as cited in Lake-Hammond & Waite, 2010, p. 90).

Exhibition design process in museums is a participatory process involving the curator, the designer and the user. While the curator is the expert on the exhibition content, the main concern of the exhibition designer should be to establish a relationship between the content created by the curator and the audience. This highlights the importance of communicating exhibition information in a clear and coherent way (Lake-Hammond & Waite, 2010). However, in contrast to the linear exhibition design scheme of Lake-Hammond and Waite, this study proposes a circular setup. Users can also interact with the curator during the curation process (Figure 1). Today there are museums that work with public during the curation phase. In this method, museums provide social participation under the name of 'community curators', for collecting data from diverse users and to develop a user base (Huang & Liem, 2022, p. 7). Therefore, this indicates that public participation on exhibition design process starts from the curation phase.

Fallowing a participatory curation process, the design phase that will connect users with the exhibition content comes into play. At this point, designers need to produce inclusive solutions, just like the participatory approach in the curation process. This will only result in inclusive designs if they are developed through discussions and feedback with community curators.

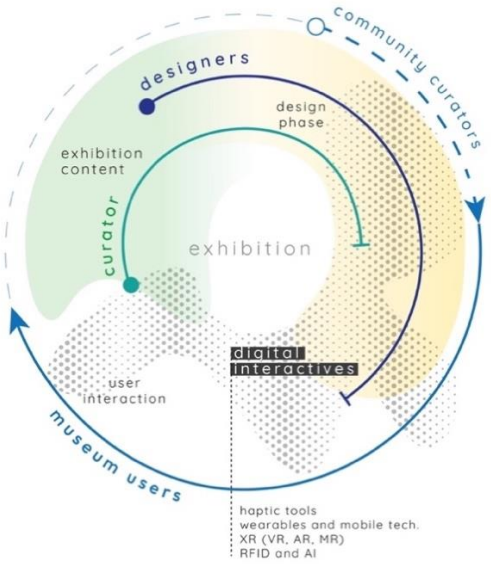

Figure 1. Exhibition design process for social museums, Author, 2024.

The concept of inclusive design is inextricably linked to accessibility. It considers human diversity across a range of factors, including ability, language, culture, gender, age, and other forms of human difference (May, 2018). The term 'inclusive design' has emerged as a unifying concept to describe the design of accessible spaces, previously referred to by various terms, including 'human-centered design', 'universal access', and 'universal design'. All these terms aim to facilitate an understanding of the diverse needs of users and provide solutions that address those needs. In 1997, a group of architects, product designers, engineers, and environmental design researchers, led by Ronald Mace at North Carolina State University (NCSU), developed the 7 Principles of Universal Design. The seven principles of universal design, as defined by Mace and colleagues at NCSU in 1997, are as follows: (1) Equitable use, (2) Flexibility in use, (3) Simple and intuitive to use, (4) Perceptible information, (5) Tolerance for error, (6) Low physical effort, (7) Size and space for approach and use (Coleman et al., 2003). The objective of these principles is to provide guidance for designing environments, products, and communications that are accessible to all. The Center for Universal Design at NCSU (1997), proposes that these guidelines can be utilized to evaluate existing designs, guide the design process, and educate designers and users about the essential characteristics of more accessible products and settings.

Inclusion is a subjective concept. Studies on inclusion practices in museums are mainly divided into two categories, social inclusion, and spatial inclusion. Social inclusion research focuses on museum exhibitions and events that support social justice and diversity for minority groups. Coleman (2018) defines social inclusion in museums as the process of countering social exclusion through cultural, social, political, and economic means. On the other hand, spatial inclusion describes practices and studies aimed at removing physical barriers and limitations in museum spaces. For this purpose, the Smithsonian Museum has prepared a guideline for ensuring inclusivity in museum spaces within the scope of the Smithsonian Accessibility Program (Smithsonian Institution Accessibility Program, 2010). The Guideline is classified into 11 categories: (1) Exhibition content, (2) Exhibition items, (3) Label text and design, (4) Audiovisuals and interactives, (5) Circulation route, (6) Furniture, (7) Color, (8) Lighting, (9) Public programming spaces, (10) Emergency egress, and (11) Children's environments.

The Smithsonian guidelines provide a comprehensive definition of barrier-free and inclusive design conditions in museum spaces, accompanied by a considerable amount of data. This includes dimensions for wheelchair users to facilitate approach to fixed furniture, the height at which artifacts should be hung for optimal viewing, accessible lighting levels, considerations for label design for individuals with cognitive disorders. As this research focuses on digital interactive systems, the audiovisuals and interactives category of the Smithsonian guidelines is within the scope of this study.

In accordance with the guidelines, exhibit materials should be presented in a way that can be easily understood by people with varying levels of intellectual abilities and conveyed through multiple sensory channels. All audio narration must be provided in a printed format. Individuals with hearing impairments

need a written translation of the narration when watching presentations that include a narrative soundtrack, to understand them better. This written translation can be displayed on the screen for all viewers to see (open captioning) or can be turned on or off as needed (closed captioning). To ensure accessibility for all visitors, it is recommended that volume controls be included allowing visitors to operate themselves for audio programs that do not have a narrator. It is necessary to provide labels on interactive and audiovisual content that does not have soundtracks, to ensure that individuals with hearing disabilities are aware that they are not missing out on any important information. Also, audiovisual materials and computer-based interactive programs, which use a combination of images and text to convey information, should have an audio description included.

It is important to ensure that instructions for using interactive features are available to all visitors, including those with cognitive disabilities. Interactives should be within reach for people who are short or use wheelchairs or are standing. The controls such as levers, buttons, and trackballs should be placed in a location that is easily reachable by wheelchair users and free from obstructions caused by furniture or shelves. If the controls are intended to be accessed from a wheelchair's front, their height should range between 380mm and 1220mm above the floor. If they are to be approached from the side, their height should range between 230mm and 1370mm above the floor.

According to the guidelines, museums should provide touch-sensitive areas for people with visual impairments or cognitive disabilities and equipment should be height adjustable. Features that require user interaction should be accessible to individuals with limited hand and muscle control, as well as those who have only one hand. Finally, it is essential to ensure that there are no obstacles, such as furniture, blocking the path to the interactives.

4. Digital Interactives Used in Museums for Social Inclusion

Digital technology today plays a central role in daily life. It has revolutionized the way we communicate, work, learn, access public services and information, and entertain ourselves. However, not everyone has equal access to these technologies and many individuals still find themselves excluded from the digital world. This exclusion can limit their participation in society, and certain groups are disproportionately affected. Studies have shown that non-users of digital technology are typically older, less educated, unemployed, disabled, and socially isolated (O'Sullivan et al., 2023). As technology and new digital opportunities develop, their use as assistive tools for inclusive design has also increased.

According to Semper (1997), museums need to comprehend the experience of visitors to make efficient use of new media technologies. He suggests that museums can become isolated from society and new media technologies can help them connect with the world by creating hybrid spaces that blend exhibits, media, communication, and on and offsite audiences. Contemporary museums have extensive galleries that offer temporary, interactive, and immersive exhibitions. They aim to engage with their visitors through interactive exhibits are incorporating digital technology into their design plans. By utilizing digital tools, they can enhance the appearance of the museum and complement its physical and structural components (Ciolfi & Bannon, 2007).

According to Rothberg and Reich (2014), utilizing universal design techniques, which involve using multiple ways to communicate information, can enhance the effectiveness of exhibits. However, they point out that this approach might lead to two issues. To begin with, certain visitors might feel inundated by the sheer amount of information presented to them, believing that they have to grasp every detail provided, without realizing that it is deliberately replicated. Additionally, some visitors with disabilities may feel left out of the experience as they perceive that the inaccessible medium contains critical information. When designers combine multiple mediums instead of providing them as distinct options for users, it may be difficult for users to trust that they are receiving the full presentation. To make interactive content accessible to everyone, it is important to divide the content into smaller parts and create multiple ways to access the same information. This approach ensures that if one method does not work, there are other alternatives available to ensure that everyone can access the content.

As sensory, cultural, and educational spaces, social museums are supported by recent digital interactive technologies. These technologies can be used as assistive tools for supporting the museum space in terms of equality for all users. Museums are utilizing an array of innovative technologies to create a more engaging and interactive experience for visitors. These tools include extended reality (XR), sensors, artificial intelligence (AI), haptic tools such as 3D printing and 3D scanning, machine learning, and wearables using several of these technologies. With these advanced technologies, museums can offer new forms of

representation that go beyond traditional display methods. Visitors can manage their experience through digital applications and interact with the content in ways that were previously impossible. They can be used alone as auxiliary tools, or together to strengthen the experience. Museum visits can be made more personalized and socially interactive. These tools can also help to reinforce the museum's identity and create a welcoming environment where visitors feel free to express themselves and interact with others. By layering digital elements on top of the physical space, museums can create a unique and immersive environment that changes the perception of the space. This transformation enables visitors to explore classical artworks in new and exciting ways, such as complex reproduction methods that make the artwork come alive. The best interactive experiences are the ones that enable visitors to participate as storytellers and immerse themselves in the experience (Jones, 2020). For example, extended reality (XR) tools can enable the creation of 3D visuals in physical space, further enhancing visitor experience. Moreover, with the help of AI and IoT technologies, museums can create personalized experiences for visitors while also preserving and showcasing their content in personalized and innovative ways.

The study will identify and examine these technologies with examples in four categories based on their interaction with museum users: Haptic tools, wearables and mobile technologies, extended reality technologies, and RFID and artificial intelligence technologies.

4.1. Haptic tools

Museums are typically designed for sense of sight. However, according to a study, incorporating haptic interaction into museum learning had a more significant effect on learning performance than non-haptic interaction (Qi et al., 2023). The study found that using an interactive 3D artifact simulation with haptic feedback resulted in improved learning performance and slightly longer engagement time. This indicates that haptic interaction could be a valuable tool for enhancing museum education programs.

It can be difficult for individuals with visual impairments to explore museums since numerous objects are concealed behind glass walls, and the available information is limited to descriptions. In order to include people who are blind or have low vision to museum experience, social museums offer new haptic tools in addition to audio descriptions. These tools allow individuals to have a personal experience with an object, comprehensively examine its details and gain a better understanding (Bruns et al., 2023).

A range of materials are utilized to offer tactile access to exhibits. These materials include embossed paper, thermoformed plastic, 3D printing, resin molding, carved wood, stone, and fabric which are shaped using 3D systems like light scanners and laser scanners (Comes, 2016, p. 60-61). For example, the Tiflológico Museum (Museum for the Blind) in Madrid, Spain, aims to cater to the needs of visually impaired visitors by incorporating tactile exhibition elements. It promotes itself as a museum that can be experienced through both sight and touch, with features that are in line with the principles of universal design. The museum offers three permanent collections: Reproductions of national and international monuments, art pieces by people who are blind or have low vision and typhlologic material. Models of international monuments, iconic buildings and works of art, from around the world are represented to scale are exhibited to be touched and explored and accompanied by additional audio and written information, Braille and macro character, to facilitate the understanding of the pieces. (Museo Tiflologico, 2024). The museum also offers a virtual visit option for people who cannot access physically.

Apart from 3D model production methods in museums, there are also digital haptic methods such as TeslaTouch. TeslaTouch operates on the electro-vibration principle and is designed to offer a variety of tactile feedback sensations to the fingers as they move across a touch surface (Bau et. al, 2010). This haptic technology offers a multitouch vibrotactile feedback. This system can be used in museums for visually impaired people to receive tactile sensations for different textures, surfaces or a story using a touch screen (Figure 2).

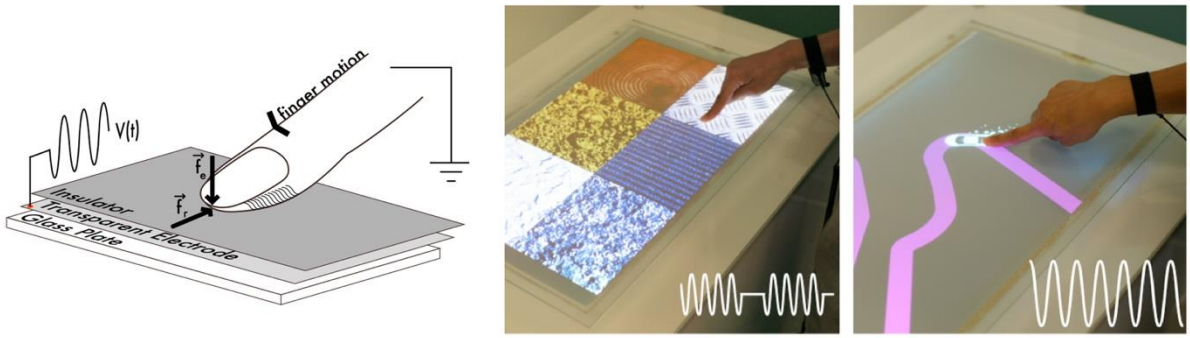

Figure 2. Tesla Touch operation principle (left) and TeslaTouch demomstration for different textures producing different sensations (right), Bau et al., 2010.

4.2. Wearables and mobile technologies

There are multiple wearable assistive technologies developed by scientists that can be used in museums. One example is a headgear system called the *Sound of Vision* (SoV). The SoV aims to assist visually impaired people by improving their perception and mobility with the help of assistive devices (Caraiman et al., 2017). The setup consists of multiple 3D cameras that constantly scan the surroundings linking objects to the sounds produced by 3D computers. These vibrations then get conveyed through a belt worn around the abdomen. The Sound of Vision technology helps people with visual impairments to detect spaces that are free from obstacles and recognize moving or high objects, which improves their overall spatial awareness (Hoffmann et al., 2018). However, the system requires a lot afford in training. The equipment is hard to adjust and carrying in museum environments is difficult.

Tate museum hosted an award-winning exhibition called Tate Sensorium in 2015. The exhibition offered an interactive multisensory experience of taste, touch, sight, and sound. The exhibition used technologies such as 3D sounds, perfume release system, and touchless haptics to create an impression of tactile sensations. Visitors could also wear a wristband that works as a biometric measurement device to record their emotional respond to the artworks. The visitors would receive a summary of their body's reaction after the experience (Tate Sensorium, 2015). A similar wristband technology is on used in Berlin Global Exhibition in Humboldt Forum, Germany as well. Visitors make choices through the exhibition using their wristbands with interactive tracking system. At the end of the exhibition, they receive personalized results that depict their choices and a networking ticket inviting them to lounge for social engagement (Humboldt Forum, 2021).

In 2017, the Andy Warhol Museum created an app called Out Loud, which functioned as a location-based audio guide (Gonzales, 2017). The exhibition included tactile replicas along with the app. The guide was made for visually impaired people and used bone conduction earphones to transmit sound through the skull, rather than through the ear canal. This made it suitable for those with certain types of hearing loss. Although the app was well-received by users, it was ultimately discarded due to maintenance issues (Llamazares de Prado et al., 2021). Today, the museum uses an audio-visual (AV) guide called Bloomberg Connects that contains tens of museums especially from the US.

Since 2021, Royal Holloway Picture Gallery is using the *Smartify app*, which aims to improve access to its collection and offers innovative audio descriptions. Rather than producing a guide to the artworks in a traditional way, they created a new audio experience for both partially sighted visitors and other users. The museum also offers musical descriptions of paintings for an alternative art experience (Figure 3). Like Royal Holloway, many museums including Louvre, Rijksmuseum and Smithsonian use Smartify app for digital museum tours for making museums more accessible through mobile technologies.

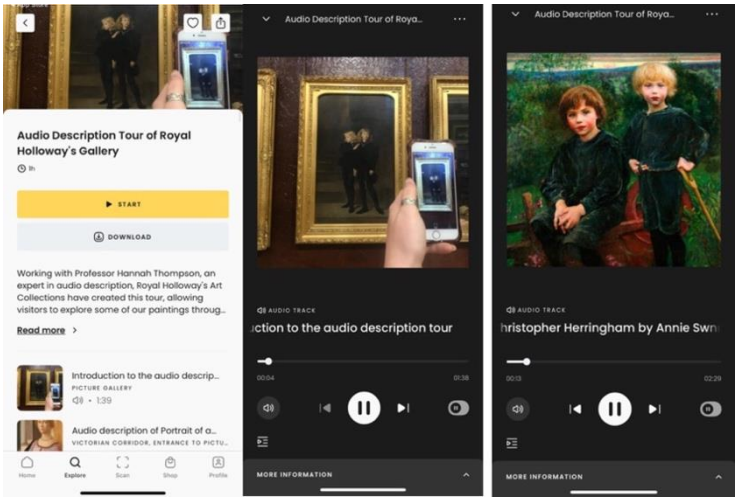

Figure 3. Screenshots from the Audio Description Tour of Royal Holloway's Gallery in Smartify app, Royal Holloway Picture Gallery, 2024.

4.3. Extended reality (XR) technologies

XR (Extended reality) is an umbrella term that refers to a collection of technologies that enable various forms of immersion and interaction, including Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) (Silva & Teixeira, 2022). Various technologies are being utilized to produce diverse types of experiences that stimulate multiple senses.Scientists are taking advantage of XR not only to provide individuals with disabilities with access, but also to offer them pleasurable and immersive multisensory exploratory experiences.

In their study on virtual reality museums for visually impaired, Zaal et al (2022) found out that there is potential in enhancing a traditional VR museum experience by incorporating audio and haptic feedback to assist with navigation, especially for the visually impaired. VR can be both experienced either in a fully immersive physical space or via digital tools thattransport users a completely digital immersive environment. These alternative approaches can be used in museums depending on the circumstancesand desired experiences.

In 2018, The National Gallery of Prague introduced an innovative haptic VR experience called *Touching Masterpieces* (Figure 4). This experience allowed individuals with visual impairments to explore and 'touch' some of the museum's most renowned sculptures, including Michelangelo's David and the bust of Nefertiti. The system does not work with a usual headset (HMD), instead it uses a pair of gloves for experiencing vibrations through haptic maps created specifically for the project. The VR gloves equipped with haptic technology provide a tactile sensation that replicates the sense of touch in three dimensions (Coates, 2019).

Figure 4. Touching Masterpieces, the haptic VR experience screenshots, Geometry Prague, 2018.

Despite the limitations of VR in physical environments, AR technology is increasingly used in museums to overlay information onto real spacesthrough smartphones and tablets. additionally, there is also a concept called *tangible AR*. Physical objects can be used to control virtual information in augmented reality (AR)

environments. These objects are marked with cards and available in 3D space to access virtual content. This method of interaction is made possible by tangible AR interfaces, which help create efficient tools for interacting with virtual objects. By using physical objects to control virtual environments, users can easily manipulate the digital world through intuitive physical actions (Xu et al., 2023).

Another interactive technology that can be used in museums for social inclusion is MR. An MR environment combines the virtual and physical domains in a way that is spatially coherent. The fusion of these domains creates an environment where both the virtual and physical elements coexist seamlessly (Holz et al., 2011).

Saviano et al conducted a study in 2023 on an MR project called *MiRA* which aims to creating an accessible museum for disadvantaged individuals. MiRA is a project that offers a Mixed Reality experience without the need for head-mounted devices (HMDs). It uses an interactive system that employs a perspective illusion to virtually complete displayed artifacts. The system uses a depth camera, a computer, a projector, (or other screens). It works by spatial tracking and screens/projections, allowing for perspective matching without a device attached to the body. Therefore, it allows a wide range of users to interact with the exhibition. Through the creation of deviceless interactions, individuals can avoid the negative symptoms associated with virtual reality (VR) headsets, such as cybersickness, which is caused by a sensory conflict between what is perceived by the eyes and the body. This allows users to remain connected to the real world without experiencing any unwanted side effects (Saviano et al., 2023).

4.4. Radio frequency identification (RFID) and artificial intelligence (AI)

Radio Frequency Identification (RFID) technology enables the monitoring and identification of items through a tag that contains a microprocessor and antenna. This is achieved by using wireless communication technology (RF signals) carried on the tag. The primary objective of RFID systems is to automatically identify and track objects, while creating, collecting, and managing dynamic information or data about them. With this technology and communication infrastructure, data collection, service distribution, object tracking, and system management can be carried out without human intervention and without providing object visibility. This reduces the error rate and increases the speed and quality of service (Jones et al., 2005).

An example of RFID usage in museums can be found in the ‘Science of Survival’ exhibition at the Science Museum, London (Figure 5). In this exhibition, visitors were asked to make lifestyle choices related to different zones of the exhibition, such as eating, drinking, transport, and building. The RFID card and reader recorded each decision compiling them into the Future City display, which showed the environmental impact of these choices on a community in 2050. This helped visitors engage with the exhibition's themes by making connections between different areas of the exhibition (Hatto and Partners, n.d.).

Figure 5. Science of Survival Exhibition, Hatto and Partners, n.d.

Museums are increasingly prioritizing accessibility in their exhibits and artificial intelligence (AI) is playing a pivotal role in this effort. AI technology has the potential revolutionize the operation of museums and cultural heritage sites by enabling real-time data analytics. This can help museums adopt a more human-centered approach in their activities and provide a better experience to their visitors. By using sentiment analysis, museums can analyze how visitors interact with the artifacts on display and determine their interests on an individual level. This can help in directing visitors to areas of the museum that align with their interests, thereby mitigating the risk of them becoming dissatisfied with their experience (O’Neill et

al., 2023). Therefore, the use of AI in museums can improve overall experience of all museum users using real-time data.

One example of the use of AI in museums is the IRIS+ chatbot at The Museum of Tomorrow in Rio de Janeiro. IRIS+ is an upgraded version of the original IRIS digital assistant that was introduced when the museum opened in 2017. Using AI technology, IRIS+ collects data from visitors' interactions and uses it to personalize their experience and connect them with social and environmental initiatives. IRIS+ is used through a RFID card that is given to every visitor at the admission and visitors use the card to identify themselves and personalize their museum visit at every step of their visit (Morena, 2018) (Figure 6).

Figure 6. The use of IRIS+ through the RFID identification card, Morena, 2018.

Museums can benefit from AI-powered translation tools, which assist visitors facing language barriers. These tools provide accurate translations of information materials and signs, making it easier for visitors to comprehend and enjoy the exhibits. Moreover, AI-powered image description tools can analyze images and create detailed audio descriptions, allowing visually impaired visitors to experience exhibits through sound.

5. Conclusion

This study explores how social museums as multinational, sensitive, cultural, and educational centers try to find new ways for visitor engagement using digital interactives such as haptic tools, wearables and mobile technologies, XR, RFID and AI technologies.

The research indicates that people with visual impairments can better understand exhibition content and feel more included through the use of haptic tools such as 3D printed materials, 3D laser scanners and digital screens with multi-touch vibrotactile feedback. Since these technologies also influence the content and organization of exhibitions, they can be defined as spatial interventions rather than wearable technologies.

the data suggests that designing and offering alternative solutions for different user types. Wearable assistive devices such as location-based audio guides and data-collecting wristbands can offer effective ways to transform and diversify the museum experience for alternative needs depending on the users' preferences.

It is seen that XR applications offer comprehensive systems that can activate alternative senses within the framework of users' needs. They allow new opportunities and sensations for social inclusion by creating more immersive museum environments. Especially MR systems without HMDs offer an easy immersion and access opportunity for a much diverse range of users.

Collecting user-generated data is critical for social museums that aim to prioritize users and shape their spaces and exhibitions along with them. RFID and AI are effective methods that can be used in this context. With these systems, museum visits can be personalized for all segments of society, and it is also possible for everyone to have a different museum experience in the same place during repeated museum visits. These tools can significantly improve the museum-going experience for all visitors.

Examples from the research indicate that digital interactive tools offer diverse solutions for creating inclusive museum environments contributing to the social aspect of museum spaces. Most of these tools are solutions for a specific needs and user types. Therefore, while designing social museums for inclusivity,

designers and museum management should get feedback from the community, identify the actual users, and define the user needs. It is essential that designers, curators and museum users contribute to the exhibition content and design through participatory processes, and that the museum interior design process is also inclusive in the formation of a social museum. Also, the impact of digital assistive tools used to increase inclusivity in museum spaces on the spatial and aesthetic experience in museums should not be ignored. In this context, the examples identified in the research to increase social inclusion are still open to improvement in terms of aesthetic experience and ease of use, while allowing people who are excluded from access to information to be included in the museum experience.

All these digital interactive tools and examples show that museums are adapting a wide range of digital systems into their interiors to increase spatial inclusivity. However, the motivation behind digital content should not be just trying to act on a digital trend for the sake of it but to enhance the museum experience for all kinds of users.

References

American Alliance of Museums. (2018). *Diversity, equity, accessibility, and inclusion*. https://www.aam-us.org/wp-content/uploads/2018/04/BRIEF-DIVERSITY-INCLUSION.pdf

American Alliance of Museums. (2022). *Excellence in DEAI.* https://www.aam-us.org/wp-content/uploads/2022/07/AAM-Excellence-in-DEAI-Report.pdf

Barroso, E., & Vaillant, E. (1993). Musées et sociétés: actes du colloque Mulhouse Ungersheim, juin 1991 Répertoire analytique des musées, bilans et projets, 1980-1993 [Museums and societies: proceedings of the Mulhouse Ungersheim conference, June 1991 Analytical directory of museums, reports and projects, 1980-1993] France Direction des musées (Ed.). Direction des musées de France: Ministère de l'éducation nationale et de la culture.

Bau, O., Poupyrev, I., Israr, A. & Harrison, C. (2010). Teslatouch: Electrovibration for touch surfaces. In: *Proceedings of the 23rd annual ACM symposium on user interface software and technology (UIST'10)*. ACM, New York, pp. 283–292. https://doi.org/10.1145/1866029.1866074

Bruns, A., Spiesberger, A.A., Triantafyllopoulos, A., Müller, P. & Björn W. Schuller. (2023). "Do touch!"- 3D scanning and printing technologies for the haptic representation of cultural assets: A Study with blind target users. In *Proceedings of the 5th workshop on analysis, understanding and promotion of heritage contents (SUMAC '23).* Association for Computing Machinery, New York, NY, USA, 21–28. https://doi.org/10.1145/3607542.3617351

Caraiman, S., Morar, A., Owczarek, M., Burlacu, A., Rzeszotarski, D., Botezatu, N., Herghelegiu, P., Moldoveanu, F., Strumillo, P. & Moldoveanu, A. (2017). Computer vision for the visually impaired: The sound of vision system, *IEEE International Conference on Computer Vision Workshops (ICCVW)*, Venice, Italy, 2017, pp. 1480-1489, https://doi.org/10.1109/ICCVW.2017.175

Center for Universal Design in NCSU. (1997). *The 7 Principles*. https://universaldesign.ie/about-universal-design/the-7-principles

Cerdan Chiscano, M. & Jiménez-Zarco, A.I. (2021). Towards an inclusive museum management strategy. An exploratory study of consumption experience in visitors with disabilities. The case of the CosmoCaixa Science Museum. *Sustainability*. 2021, 13(2) 660. https://doi.org/10.3390/su13020660

Cho, H. & Jolley, A. (2016). Museum education for children with disabilities: Development of the nature senses traveling trunk. *Journal of Museum Education*, 41(3), 220–229. https://doi.org/10.1080/10598650.2016.1193313

Ciolfi L. & Bannon L. J. (2007). Designing hybrid places: Merging interaction design, ubiquitous technologies and geographies of the museum space, *CoDesign*, 3(3), 159-180.

Coates, C. (2019). Best practice in making museums more accessible to visually impaired visitors, MuseumNext. Retrieved from (May 5, 2024) https://www.museumnext.com/article/making-museums-accessible-to-visually-impaired-visitors/

Coleman, R., Lebbon, C., Clarkson, J. & Keates, S. (2003). From margins to mainstream. In Clarkson, P. J., Coleman, R., Keates, S., & Lebbon, C. (2013). *Inclusive design: Design for the whole population*. Springer, Cambidge, UK, (13).

Coleman, L.E. (2018). *Understanding and implementing inclusion in museums*. Rowman & Littlefield.

Comes, R. (2016). Haptic devices and tactile experiences in museum exhibitions. *Journal of Ancient History and Archaeology,* 3(4), 60-64.

Edelstein, R. (2022). New foundations: Principles for disability-inclusive museum practice. *Journal of Museum Education*, 47(2), 192–205. https://doi.org/10.1080/10598650.2022.2073093

Geometry Prague. (2018). Touching masterpieces. [Video]. *YouTube*. https://www.youtube.com/watch?v=ZukE86YTvhk

Gonzales, D. (2017). A path with choice: What we learned from designing an inclusive audio guide (MW17: Museum and the Web). *Massachusetts Institute of Technology*. https://mw17.mwconf.org/paper/a-path-with-choice-what-we-learned-from-designing-an-inclusive-audio-guide/

Güneröz, C. (2023). Müze ve toplum ilişkilerinde eğitim, sosyal hareket ve katılımın yeni boyutları [New Dimensions of education, social movement, and participation in museum and community relations]. *yedi Sanat, Tasarım ve Bilim Dergisi*, 29 (p. 169-180). https://doi.org/10.17484/yedi.1076181

Hatto and Partners. (n.d.). *Science of survival*. Science Museum. Retrieved from (May 21, 2024) https://www.hattoandpartners.com/science-of-survival

Hoffmann, R., Spagnol, S., Kristjánsson, A. & Unnthorsson, R. (2018). Evaluation of an audio-haptic sensory substitution device for enhancing spatial awareness for the visually impaired. *Optometry and Vision Science,* 95(9) (p. 757-765). https://www.doi.org/10.1097/OPX.0000000000001284

Holz, T., Campbell, A., O'Hare, G., Stafford, J., Martin, A. & Dragone, M. (2011). MiRA-mixed reality agents. *International Journal of Human-Computer Studies*. 69. 251–268. https://doi.org/10.1016/j.ijhcs.2010.10.001

Huang, H.Y. & Liem, C.C. (2022). Social inclusion in curated contexts: Insights from museum practices. In *Proceedings of the 2022 ACM Conference on Fairness, Accountability, and Transparency,* 300-309.

Humboldt Forum. (2021). *Interactive elements at the Berlin Global Exhibition.* https://www.humboldtforum.org/wp-content/uploads/2020/09/Interactive-elements_BERLIN-GLOBAL.pdf

Jones, P., Clarke, H.C., Hillier, D. & Comfort, D. (2005). The benefits, challenges and impacts of radio frequency identification technology (RFID) for retailers in the UK, *Marketing Intelligence & Planning*, 23(4).

Jones, B. (2020). Scaffolding to build inclusive interactives: Ben Jones' digital design approach. In *Inclusive Digital Interactives Best Practices + Research, Access,* Smithsonian, Institute for Human Centered Design and MuseWeb, (20).

Lake-Hammond, A. & Waite, N. (2010). Exhibition design: Bridging the knowledge gap, *The Design Journal* 13(1), 77–98. https://doi.org/10.2752/146069210X12580336766400

Llamazares de Prado, J. E., & Arias Gago, A. R. (2023). Technology and education as elements in museum cultural inclusion. *Education and Urban Society*, 55(2), 238-258. https://doi.org/10.1177/00131245211004576

Lurio, A. (2016). Engaging children with autism at historic sites: Developing an audience-appropriate curriculum. *Journal of Museum Education*. 41(3), 165–173.

May, M. (2018, April, 2). Breaking down accessibility, universality, and inclusion in design. *Adobe Blog*. https://blog.adobe.com/en/publish/2018/04/02/different-breaking-accessibility-universality-inclusion-design

Morena, D. (2018). *IRIS+ part one: Designing + coding a museum AI*. Center for the Future of Museums Blog, American Alliance of Museums. https://www.aam-us.org/2018/06/12/iris-part-one-designing-coding-a-museum-ai/

Museo Tiflologico. (2024). *The museum*. https://museo.once.es/otras-webs/english

O'Neill B., Stapleton L., Carew, P.J., Walsh Shanahan, B., Pearson, S., Byrne, D. & Doyle-Kent, M. (2023). Artificial intelligence and the world wide web: Brain and friend? In *Proceedings of the 22nd World Congress of the International Federation of Automatic Control—IFAC World Congress 2023*. Yokohama Japan: IFAC.

O'Sullivan, D., Murphy, E., Curley, A., Gilligan, J., Gordon, D., Becevel, A., Hensman, S., Rocha, M., Rivera, C., Collins, M., Gibson, J.P., Dodig-Crnkovic, G., Kearney, G. & Boland, S. (2023). Inclusion4EU: Co-designing a framework for inclusive software design and development. Studies in Health Technology and Informatics. In Archambault, D. & Kouroupetroglou, G. (Ed.) *Volume 306: Assistive Technology: Shaping a Sustainable and Inclusive World*, Ios Press Ebooks, https://www.doi.org/10.3233/SHTI230668

Rothberg, M. & Reich, C. (2014). Making museum exhibits accessible for all: Approaches to multi-modal exhibit personalization. *Open Exibits*. http://www.openexhibits.org/wp-content/uploads/papers/MakingMuseumExhibitsAccessibleForAll.pdf

Royal Holloway Picture Gallery. (2024). *Audio Description Tour of Royal Holloway's Gallery*. https://app.smartify.org/tr/venues/royal-holloway-picture-gallery

Sandell, R. (2011). On ethics, activism and human rights. In Marstine, J. (Ed.) *The Routledge Companion to Museum Ethics: Redefining Ethics for the Twenty-First Century Museum* (p. 129-145), Routledge.

Semper, R. (1997). Hybrid spaces, networked places: New media and museums. *The Journal of Museum Education,* 22(1) (17–18). http://www.jstor.org/stable/40479085

Silva, M. & Teixeira, L. (2022). Extended reality (XR) experiences in museums for cultural heritage: A systematic review. In Lv, Z., Song, H. (Eds). *Intelligent Technologies for Interactive Entertainment.* INTETAIN 2021. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering. 429. Springer, Cham. https://doi.org/10.1007/978-3-030-99188-3_5

Smithsonian Institution Accessibility program. (2010). *Smithsonian guidelines for accessible exhibition design.* https://www.sifacilities.si.edu/sites/default/files/Files/Accessibility/accessible-exhibition-design1.pdf

Tate Sensorium. (2015). *IK Prize 2015: Tate Sensorium opens at Tate Britain today.* https://www.tate.org.uk/press/press-releases/ik-prize-2015-tate-sensorium-opens-tate-britain-today

United Nations Development Programme. (2022). *Digital Strategy 2022-2025*. United Nations Development Programme, One United Nations Plaza New York, NY 10017.

United Nations Development Programme. (2023). *From vision to action: Explaining Undp's digital transformation framework*. https://www.undp.org/sites/g/files/zskgke326/files/2023-11/%5Bconcept%20note%5D%20digital%20transformation%20framework.pdf

Qi, B., Zhang, M., Zhu, X., Jiang, Y. & Xiang, X. (2023). Effects of haptic interaction on learning performance and satisfaction with 3D collections. *Education and Information Technologies,* 29, 7793–7811. https://doi.org/10.1007/s10639-023-11921-3

Xu, N., Li, Y., Wei, X., Xie, L., Yu, L. & Ning Liang, H. (2023). CubeMuseum AR: A tangible augmented reality interface for cultural heritage learning and museum gifting, *International Journal of Human–Computer Interaction*, https://www.doi.org/10.1080/10447318.2023.217135

Zaal, T., Akdag Salah T. T. & Hürst, W. (2022). Toward inclusivity: Virtual reality museums for the visually impaired, *2022 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR),* CA, USA, 2022, pp. 225-233, https://www.doi.org/10.1109/AIVR56993.2022.00047

Ziebarth, B., Majewski, J., Marquis, R. & Proctor, N. (Eds.) (2020). Inclusive digital interactives: Best practices + research, A collaboration of access Smithsonian Institute for human centered design and MuseWeb.