Inclusive Memory

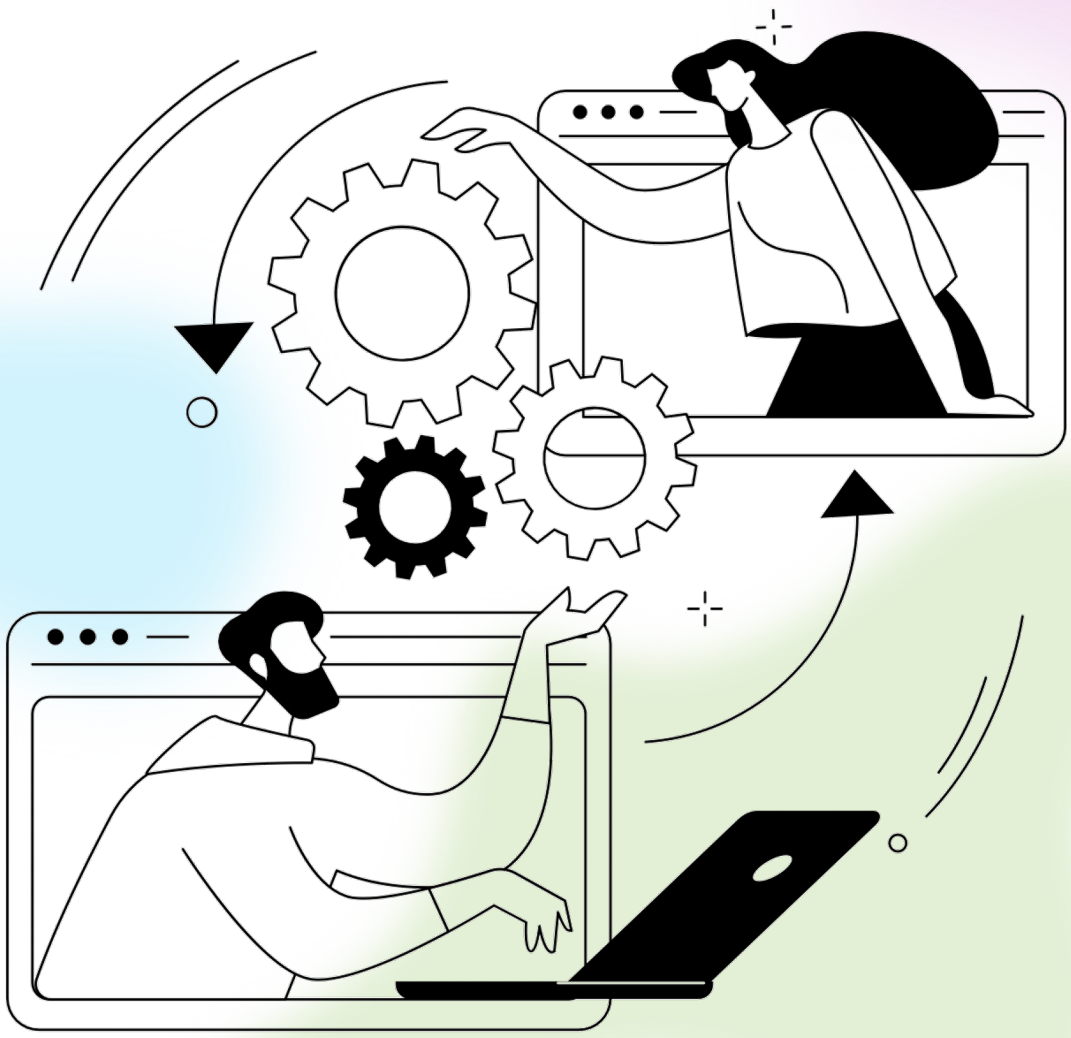
inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Erasmus+
Project n. 2021-1-IT02-KA220-HED-000031991

INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2

Handbook on the use of technology for inclusive educational activities in museum context



inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Index

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2.A1 – Investigation on the use of technology to support the development of visitor's cross sectional skills and wellbeing

Results 2 | Activity one	
Title	
Delivery	July 2022
Leader /Co-Leader	Università degli Studi Unimore, UNED
Review	September 2022

The creation of these resources has been funded by the ERASMUS+ grant program of the European Union under grant no. 2021-1-IT02-KA220-HED-000031991. Neither the European Commission nor the project's national funding agency are responsible for the content or liable for any losses or damage resulting from the use of these resources.

Print

This publication is number 01.1 of the strategic collaboration founded by the ERASMUS+ grant program of the European Union under grant no. 2021-1-IT02-KA220-HED-000031991 |

PDF download

A full PDF version of the text is available and can be downloaded free of charge from the website: https://piattaformaintellect.it/portale/index.php/outputs/

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Introduction

1. Aims

The *Investigation on the use of technology to support the development of visitor's cross-sectional skills and wellbeing* aims at providing an overview of the use of digital technologies in museum activities whose explicit objective is the promotion of visitors' and participants' wellbeing, understood as related to the:

1. health sphere, i.e. in terms of psycho-physical wellbeing;
2. pedagogical field, i.e. in terms of competencies for active citizenship;
3. psychological field, i.e. in terms of emotional engagement.

2. Structure and implementation

The investigation consists of three sections.
The first part proposes three definitions of wellbeing: wellbeing in terms of psycho-physical wellbeing, competencies for active citizenship, and emotional engagement. The definitions were the results of a literature review of the most authoritative research in the field.
The second part consists of the review analysis of case studies on using technology in museums to promote wellbeing. The investigation was carried out using multiple databases: Google Scholar, Research Gate, Academia, JStor, Eric, and Scopus. Starting from a list of technologies frequently deployed in museums for different scopes, the keywords used were "*name of technology* wellbeing/didactic/education in museums". The most relevant case studies that presented empirical data were selected. For each technology was written a paragraph that summarised the purpose, the diffusion, and the objectives of the said technology; presented the most significant case studies (stating where they took place, in which type of museum, the objectives of the research, the methodology, the target, and relevant findings); and indicated the type of wellbeing the said technology promoted, and which indicators of wellbeing were measured.
The third part discusses the possible technological applications of cultural heritage for promoting wellbeing and health. It divides the analysed technologies into three groups, based on their potential use in promoting the three types of wellbeing.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Definition of wellbeing

Wellbeing can be defined as multidimensional as its research aims at personal growth and the development of individual and collective strengths. This view is supported by the World Health Organisation (WHO), which defines wellbeing as an element of health, which is a "state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity" (WHO 1946). Given its complex nature, wellbeing can be defined and understood in multiple ways. The most authoritative literature in the field articulates the concept of wellbeing in three main areas:

1. health sphere, i.e. in terms of psycho-physical wellbeing;
2. pedagogical field, i.e. in terms of competencies for active citizenship;
3. psychological field, i.e. in terms of emotional engagement.

1.1 Psycho-physical wellbeing

Positive Psychology, which is based on the theories of Seligman and Csikszentmihalyi (2000), refers to wellbeing as flourishing or optimal human functioning at an individual and community level. Regarding psycho-physical wellbeing, NEF (2009) suggests that wellbeing is "most usefully thought of as the dynamic process that gives people a sense of how their lives are going, through the interaction between their circumstances, activities and psychological resources or mental capital". The Foresight Mental Capital and wellbeing Project (2008) describes mental wellbeing as a "dynamic state, in which the individual is able to develop their potential, work productively and creatively, build strong and positive relationships with others, and contribute to their community". These definitions seem to focus more on the psychological side of wellbeing. However, this can be explained by considering the relationship of wellbeing to the term "health" (Ander *et al.* 2011). According to these authors, health is "more tangible, more bodily, more measurable", while wellbeing is "positive, free-choice, and self-described contentedness". The evidence reviewed within the Foresight project showed wellbeing to be inextricably linked to health, as "a high level of wellbeing is associated with positive functioning, which includes creative thinking, productivity, good interpersonal relationships and resilience in the face of adversity, as well as good physical health and life expectancy". Thus, by increasing one's psychological wellbeing, physical health will also benefit from it.

Psycho-physical wellbeing is conceived both on a singular and a collective level. As What Works Centre for Wellbeing states, "it's 'how we're doing' as individuals, communities and as a nation". Therefore, individual and societal wellbeing are highly connected: a well-functioning society will increase the wellbeing of the single and the satisfied individual will contribute to creating a better community. Hence, accessibility and inclusion are fundamental factors of wellbeing. The lack of barriers and the provision of additional tools to ensure cultural and physical accessibility are central to guaranteeing overall wellbeing to everyone, especially those who suffer from diseases or impairments.

This concept is closely connected to the social model of disability, which opens new perspectives on disability by actively identifying systemic barriers, derogatory attitudes, and social exclusion.

1.2 Indicators of psycho-physical wellbeing

The indicators of psycho-physical wellbeing are:

- Accessibility (Friedli, 2012);
- Feeling of belonging (Pietarinen *et al.*, 2014);
- Inclusion (Friedli, 2012);
- Level of anxiety (Ander *et al.*, 2013);
- Satisfaction (DCMS, 2015);
- Self-awareness (National Lottery Fund, 2016);
- Self-confidence (Chatterjee *et al.* 2009);
- Self-esteem (Ander *et al.*, 2013);
- Sense of community (NEF, 2009);
- Sense of identity (Ander *et al.*, 2013).

2.1 Wellbeing in terms of competencies for active citizenship

In the pedagogical field, wellbeing can be seen as competency in a democratic society. As underlined by the Council of Europe, soliciting transversal competencies within a democratic cultural context improves pupils' and people's wellbeing, which includes being active, responsible, connected, resilient, appreciated, respected, and aware (DES & NCCA, 2017). Moreover, the CoE considers wellbeing as the ability to participate in an active community and culture. The 4C skills (Communication, Collaboration, Critical thinking, Creativity) are the basic competencies for learning. They are fundamental in any educational context and lifelong learning, and are a prerequisite for more complex competencies, supporting the development of individuals as active and aware citizens (Poce, 2018). Similarly, Trilling and Fadel (2009) state that the 4C skills allow the development of more complex competencies and therefore self-realisation, social inclusion , and future employment. Furthermore, "learning in cultural organisations is associated with creativity and innovative thinking and there can also be seen the development of attitudes and values" (RCMG 2003). Communication is defined as the ability to provide and share information (McCroskey, 1988). Collaboration is intended as the process of working together towards a goal either at an individual or group level (Griffin *et al.*, 2015; Kuhn, 2015). Creativity can be described as a process that leads to a solution or product that is useful and innovative (Stein, 1953) and closely linked to problem-solving skills. Critical thinking is the most difficult skill to define. However, the definition provided by Scriven and Paul (1987) can be deemed valid. According to them, it can be considered as the intellectually disciplined process of actively and skillfully conceptualising, applying, analysing, synthesising, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

2.2 Indicators of wellbeing in terms of competencies for active citizenship

Based on that, when evaluating wellbeing in the Education field, it is possible to identify the following indicators:

- Activity (DES & NCCA, 2017);
- Awareness (DES & NCCA, 2017);
- Collaboration (Poce, 2018);
- Communication (Poce, 2018);
- Connection (DES & NCCA, 2017);
- Creativity (Poce, 2018);
- Critical Thinking (Poce, 2018);
- Digital competencies (Poce, 2018);
- Resilience (DES & NCCA, 2017);
- Respect (DES & NCCA, 2017);
- Responsibility (DES & NCCA, 2017).

3.1 Wellbeing in terms of emotional engagement

The study of wellbeing as experiencing positive emotions and pleasure in the psychological field has a long tradition, starting from two fundamental philosophical conceptions considered by 20th and 21st-century researchers: *hedonism* and *eudaimonia* (Sánchez-Elvira, 2004; Ryan & Deci, 2001). *Hedonism* conceives wellbeing as a positive subjective experience linked to positive emotional states and life satisfaction achieved through the pursuit of pleasure, gratification, and comfort. Thus, the levels of positive and negative affect and the degree of overall life satisfaction define individual subjective wellbeing (Diener & Scollon, 2014). The role of positive emotions is, on the other hand, the basis of Fredrickson's broaden-and-build theory indicating that positive emotions broaden one's awareness and encourage novel, exploratory thoughts, and actions in a growing spiral (Fredrickson, 2001).

From the *eudaimonic* point of view, derived from Aristotle's conception, wellbeing and happiness refers to what makes life worth living through the realisation of one's own potential. In this sense, *eudaimonic* wellbeing results from engaging in effortful and sometimes difficult but worthwhile challenges for the individual. The current *eudaimonic* conception evolved from previous theories of the 20th-century humanistic psychologists.

The combination of these two different wellbeing approaches has given rise to different theoretical models, highlighting the PERMA model proposed by Martin Seligman in 2011, composed of five fundamental elements for wellbeing and happiness: Positive Emotions (P), Engagement (E)?, Positive Personal Relationships (R), Meaning and Purpose in Life (M) and Achievement (A). This model is associated with the concept of *Flourishing* (Seligman, 2011), a state of positive mental health that promotes personal and community growth, despite the challenges and difficulties that may arise.

At present, systematic reviews are supporting the positive association between arts and humanities engagement with *flourishing* (Cotter & Pawelskim 2021).

Wellbeing in informal learning contexts such as museums can be perceived as emotional engagement. The latter, in any education context, encompasses the affective factors of engagement, including enjoyment, support, belonging and attitudes towards teachers/educators, peers, and learning in general (Pietarinen *et al.*, 2014). The UCL Museum wellbeing Measures Toolkit (2013) measures psychological wellbeing by focusing on levels of self-reported changes in mood and emotion as these aspects of wellbeing are the ones that are more likely to change as a result of a short intervention, such as participating in a museum or gallery activity.

wellbeing as emotional engagement during sessions with cultural heritage can consist of: "positive emotions and cheering up; giving new perspectives and thoughts about their lives; producing new learning, interest and desire to learn; initiating personal memories and recollections giving a renewed sense of identity; 'passing time much quicker'; creating a positive mood; bringing out a sense of vitality and energy to override depressive or lethargic feelings; relieving anxiety" (Ander *et al.*, 2013).

3.2 Indicators of wellbeing in terms of emotional wellbeing

Based on that, when evaluating emotional engagement in museum contexts, it is possible to identify the following indicators:

- Achievement (Seligman, 2011);
- Desire to learn (Ander *et al.*, 2013);
- Feeling of belonging (Pietarinen *et al.*, 2014);
- Inspiration (Thomson, Chatterjee, 2013);
- Interest (Ander *et al.*, 2013);
- Levels of anxiety (Ander *et al.*, 2013);
- Meaning and Purpose in Life (Seligman, 2011);
- Motivation (Thomson, Chatterjee, 2013);
- Participation (Pietarinen *et al.*, 2014);
- Positive emotions (Seligman, 2011);
- Positive Personal Relationship (Seligman, 2011);
- Sense of vitality (Ander *et al.*, 2013).

4. References

Ander, E., Thomson, L., Noble, G., Lanceley, A., Menon, U. & Chatterjee, H. (2011). Generic wellbeing outcomes: towards a conceptual framework for wellbeing outcomes in museums. *Museum Management and Curatorship*, 26:3, 237-259.

Ander, E., Thomson, L., Noble, G., Lanceley, A., Menon, U. & Chatterjee, H. (2013). Heritage, health and wellbeing: assessing the impact of a heritage focused intervention on health and wellbeing. *International Journal of Heritage Studies*, 19:3, 229-242.

Chatterjee, H. J., Vreeland, S. and Noble, G., 2009. Museopathy: Exploring the Healing Potential of Handling Museum Objects. *Museum and Society*, 7:3, 164-177.

Cotter, K.N. & Pawelski, J. (2021). Art museums as institutions for human flourishing. *The Journal of Positive Psychology*, 17. DOI 10.1080/17439760.2021.2016911

DCMS. (2015). *Taking Part 2014/15, Focus On: Wellbeing*. Statistical Release.

Department of Education and Skills & National Council for Curriculum and Assessment. (2017). *Guidelines for Wellbeing in Junior Cycle*.

Diener, E. & Scollon, C. N. (2014). The what, why, when, and how of teaching the science of subjective wellbeing. *Teaching of Psychology, 41*(2), 175-183. https://doi.org/10.1177/0098628314530346

Foresight Mental Capital and Wellbeing Project. (2008). Final Project report. The Government Office for Science. London.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist, 56* (3), 218. https://doi.org/10.1037/0003-066X.56.3.218

Friedli, L. (2012). *Social prescribing for mental health – a guide to commissioning and delivery*. Care Services Improvement Partnership, North West Development Centre.

Griffin, P. & Care, E. (2015). *Assessment and teaching of 21st Century Skills. Methods and Approaches*. Dodrecht: Springer Netherlands.

Kuhn, D. (2015). Thinking together and alone. *Educational Researcher*, 44, 46-53.

McCroskey, J.C. & McCroskey, L.L. (1988). Selfreport as an approach to measuring communication competence. *Communication Research Report*, 5:2, 108-113.

National Lottery Fund. (2016). *Improving futures, evaluation, and learning. About the Improving Futures programme*.

New Economics Foundation (NEF). 2009. *National accounts of wellbeing: What is wellbeing?* London.

Pietarinen, J., Soini, T., & Pyhalto, K. (2014). Students' emotional and cognitive engagement as the determinants of wellbeing and achievement in school. *International Journal of Educational Research*, 67, 40-51.

Poce, A. (2018). *Il patrimonio culturale per lo sviluppo delle competenze nella scuola primaria*. Milano: Franco Angeli.

Research Centre for Museums and Galleries (RCMG). (2003). *Measuring the outcomes and impact of learning in museums, archives, and libraries: The learning impact research project end of project paper*. RCMG.

Ryan, R. M. y Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic wellbeing. *Annual review of psychology, 52*, 141-166. doi:10.1146/annurev.psych.52.1.141

Sánchez-Elvira, A. (2004). Los pilares y recursos de la psicología positiva en el crecimiento personal. In M.Rodríguez Zafra (Ed.) *Crecimiento personal: Aportaciones de oriente y occidente*, (pp. 45-80). Desclée De Brouwer.

Scriven, M. and Paul, R. (1987). *Defining Critical Thinking*. 8th Annual International Conference on Critical Thinking and Education Reform.

Seligman, M. E. P. (2011). *Flourish: A visionary new understanding of happiness and wellbeing.* New York: Free Press.

Seligman, M. E. P. y Csikszentmihalyi, M. (2000). Positive psychology: An introduction. *American Psychologist, 55*, 5-14. https://doi.org/10.1007/978-94-017-9088-8_18

Stein, M.I. (1953). Creativity and culture. *The Journal of Psychology*, 36:2, 311-322.

Thomson, L., & Chatterjee, H.J. (2013). *UCL Museum Wellbeing Measures Toolkit*. London: UCL.

Trilling, B. & Fade, C. (2009). *21st Century Skills: Learning For Life in Our Times*. San Francisco: Jossey-Bass.

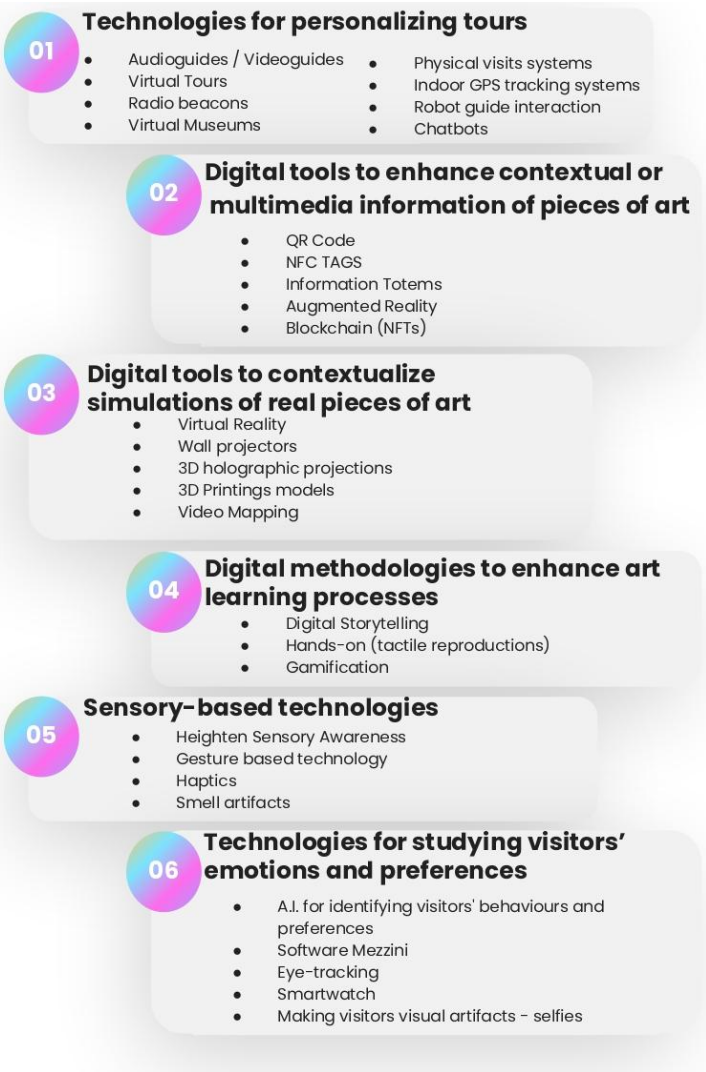
World Health Organisation (WHO). 1946. *Constitution of the World Health Organization*. New York.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Literature Review Analysis

The literature under review is organised into six clusters and concerns different technologies that might be applied to cultural heritage to promote wellbeing and health. The state-of-the-art shows that the technologies addressed below can be adopted to achieve objectives that could fall into the categories of wellbeing and health as defined above, even though not directly.

- Technologies for personalising tours;
- Digital tools to enhance contextual or multimedia information of pieces of art;
- Digital tools to contextualise simulations of real pieces of art;
- Digital methodologies to enhance learning processes;
- Sensory-based technologies;
- Technologies for studying visitors' emotions and preferences.



inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

1. Technologies for personalising tours and recognising the most popular museum objects

1.1 Audioguides

Audio descriptive guides are used to enhance access and memorability for sighted visitors as well as expand crucial access provisions for blind and partially sighted people.
At the Museum of London's Henry Grant archive, research on three groups of visitors (127 participants in total) was conducted. They viewed nine photographs from the museum collections with either no audio, a standard audio guide or an audio descriptive guide. Findings show that enjoyment and emotional responses were similar for all groups. However, one month later, audio participants recalled more photos and were more likely to have re-engaged with the collection.
The benefits of using audio guides instead of human tour guides to foster children's engagement and learning outcomes were explored through an experiment in a natural science museum in Portugal. It was conducted with 25 children from a school to understand if audio guides affected children's engagement and learning outcomes. Findings from a pre-test and post-test analysis for learning, applied scales and qualitative observation show that children using the audio guide were keen to repeat the tour, and highlight differences in the learning outcomes. Another research group developed an automatic museum audio guide consisting of a headset equipped with a camera that captures exhibit pictures and the eyes of things computer vision device (EoT). Two different use case scenarios were implemented. The main testing was performed with a piloting phase at

the Albertina Museum in Vienna. Results show that the developed system ensures simplicity of use, as users preferred it over traditional audioguides.
Audioguides can promote psychological wellbeing in terms of satisfaction, inclusivity and accessibility, develop competencies for active citizenship and foster emotional engagement - especially in terms of interest, desire to learn and sense of vitality.
Audioguides have been widespread in many museums for decades and are currently undergoing a format revision thanks to the rise of new technologies. Nowadays, writing a script and getting approval across different departments within the museum organisation is perhaps the most time-consuming part of the process. However, the other phases can be completed with no costs or within an affordable budget, as shown at the following link: https://medium.com/@hennawang/every-museum-can-do-this-3106c1ccba31.

References

Cesario, V., Coelho, A., Nisi, V. (2017). Audio Guides and Human Tour Guides: Measuring Children's Engagement & Learning at a Museum Setting. *CHITALY 2017At*: Cagliary, Italy, (1910). https://www.researchgate.net/publication/320558390_Audio_Guides_and_Human_Tour_Guides_Measuring_Children%27s_Engagement_Learning_at_a_Museum_Setting

Hutchinson,R., Eardley, A.F. (2021). Inclusive museum audioguides: 'guided looking' through audio description enhances memorability of artworks for sighted audiences. *Museum Management and Curatorship*. https://www.researchgate.net/publication/349754601_Inclusive_museum_audio_guides_'guided_looking'_through_audio_description_enhances_memorability_of_artworks_for_sighted_audiences

Vallez, N., Krauss, S., Espinosa-Aranda, J. L., Pagani, A., Seirafi, K., & Deniz, O. (2020). Automatic Museum Audio Guide. *Sensors*, 20(3), 779. https://doi.org/10.3390/s20030779

1.2 Videoguides

Videoguides are multimedia guides that enable the playback of visual content such as images and videos, along with and synchronised with audio content. Especially in more recent times, the development of video guides has also led to the implementation and integration of virtual and augmented reality experiences, for which different types of technological tools are used, such as smartphones, tablets or smart glasses. In general, besides improving accessibility and inclusion, they provide an enhanced and improved learning experience for the visitors, increasing efficacy and satisfaction dimensions - and so, in terms of wellbeing, motivation and participation, as shown in the following case studies.
As a first case study, an example of one of the implementations of videoguides before the various AR and VR technologies took hold is presented: the case of the Torre Aquila, part of the Buonconsiglio Castle in Trento, Italy. At the entrance, the visitor finds a stationary computer with a large screen and is also given a Personal Digital Assistant (PDA) with infrared capability. As the visitor's position at the entrance is detected, lifelike characters on the screen start a dialogue with the visitor. When a character is selected it fades away from the stationary device and appears as an animated agent on the visitor's PDA, accompanying the visitor throughout the visit. Once a specific character is chosen, visitors begin to see a series of short, interconnected multimedia presentations depending on the exhibit that the visitor is standing in front of. 143 actual public visitors of the Torre Aquila were invited to test the adaptive multimedia guide and they were handed a questionnaire to assess their experience in using the multimedia guide along diverse dimensions: control; Involvement; ease; intention to use. The participants generally had good involvement, found it quite easy to use and expressed their intention to use it again in the future. A

positive attitude toward technology was found to be related to a greater agreement on each dimension meaning that probably this attitude enabled the visitors to be more open to the experience this new technology has to offer during the visit at the museum. In terms of wellbeing, videoguides can foster satisfaction, interest and motivation in the visitors, whilst also providing and improving accessibility and inclusion.

A study based on empirical observation and analysis of the learning behaviours (recorded on video) of 65 elementary-school students during a visit at the Shihsanhang Museum (Taipei) states that, compared to mobile guide with problem-solving strategy and paper-based learning-sheet guide, more traditional audio-visual mobile guides foster limited degree in learners interactions, but may encourage them to discuss the physical exhibits' description boards with their peers. Taking into account wellbeing in terms of competencies for active citizenship, this implies that videoguides can improve collaboration and communication.

Videoguides allow museums and exhibitions to present visitors with extra content and additional information about the object or place of interest, thus providing an enhancement of the learning experience for the visitors. However, they require that the visitors rent, carry or return a specific mobile device, or otherwise install an app on their devices - but acceptance to download apps on personal devices may be limited.

References

Stock O. et al (2007) Adaptive, intelligent presentation of information for the museum visitor in PEACH. User Modeling and User-Adapted Interaction, 17(3), 257-304. https://link.springer.com/article/10.1007/s11257-007-9029-6

Zancanaro, M., Stock, O., & Alfaro, I. (2003). A multimedia museum guide with dynamic documentaries. Contesti culturali e fruizione dei beni culturali. https://www.afs.enea.it/bordoni/napoli/art16.pdf

Sung, Y. T. *et al.* (2010). Mobile guide system using problem-solving strategy for museum learning: a sequential learning behavioural pattern analysis. *Journal of computer assisted learning*, *26*(2), 106-115. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2729.2010.00345.x

1.3 Virtual Tours

Virtual tours connect with cultural heritage when museums, sites and places of culture are not accessible for the most different reasons. They are a valuable resource for teaching and learning as they stimulate users' emotional engagement. A virtual tour is a form of semi-immersive VR technology that allows you to experience a certain location remotely. It consists of a sequence of panoramic images that are 'stitched' together to create a 'virtual' experience of any location. Pictures can be taken from your phone, high resolution cameras or 360° cameras. Users can see an entire panoramic scene or zoom in to get a closer look at a particular area. This virtual experience could be viewed through desktop computers, laptops, tablets and even mobile devices. Some virtual tours also include sound effects such as music or a narration describing products or points of interest. Many offer buttons that can be clicked on by users who want to take a still image of a particular portion of the tour. Nowadays, two main ways to create free virtual tours are through Google Street View and Matterport.

At the historical centre of the city of Rethymno in Crete, Greece, a 360° immersive video application for Head Mounted Display (HMD) was developed and tested. Design challenges emerge by this new kind of immersive media due to the 2D form of resources used for their construction, the lack of depth, the limited interaction and the need to address the sense of presence. In addition, the use of Virtual Reality (VR) headsets often causes nausea, or motion sickness effects imposing further

implications in moderate motion design tasks. This study introduced a methodological categorisation of tasks and techniques for the design of 360° immersive video applications. The evaluation results indicated that the methodology followed for the design of the 360° immersive video Rethymno virtual tour led to high level of engagement perceived by the participants. The users immersion level was satisfying with participants feeling comfortable throughout the experience and learning about the history of the city in a fun and entertaining way. Based on the analysis of the results, a set of design guidelines for the implementation of 360° immersive video virtual tours were proposed.

Using the Tampines Chinese Temple in Singapore as a case study, another study presented a detailed methodological framework to create virtual tours for the preservation of both the physical built environment and intangible historical and sociocultural elements within the space of cultural heritage sites. The valorisation of both tangible and intangible aspects of cultural heritage is meaningful in terms of wellbeing as it facilitates a deeper understanding of our past and thus a sense of belonging. Tangible data used in the creation of the virtual tour produced for the temple comprise spherical images collected via a 360° camera and two-dimensional (2D) high-resolution images obtained via a digital single-lens reflex camera. The tour also showcases intangible aspects of the temples cultural heritage, derived from references made to multiple sources, namely interviews with personnel involved in the management of heritage sites (e.g. the temple secretary) as well as historical archives (e.g. National Archives of Singapore and publications produced by the temple). The method proved to be advantageous as the relatively low pricing of the chosen software, and the use of a 360° camera and digital single-lens reflex camera enhance accessibility for heritage practitioners, facilitate future applications. Furthermore, the VT proved to be a useful pedagogical tool for the transmission of the knowledge to the young generations of ethnic Chinese Singaporeans. While offering an immersive temple experience for the younger generation, the VT evoked their curiosity about the traditional Chinese culture and subsequently attracted them to visit the temple on-site.

References

Argyriou, L., Economou, D. & Bouki, V. Design methodology for 360° immersive video applications: the case study of a cultural heritage virtual tour. *Pers Ubiquit Comput* 24, 843–859 (2020). https://doi.org/10.1007/s00779-020-01373-8

Mah, O.B.P. *et al.* (2019). Generating a virtual tour for the preservation of the (in)tangible cultural heritage of Tampines Chinese Temple in Singapore, Journal of Cultural Heritage 39, 202–211. https://www.sciencedirect.com/science/article/pii/S1296207418307787

1.4 Bluetooth and radio beacons

Individual tracking of museum visitors based on portable radio beacons is considered an asset for behavioural analyses and comfort/performance improvements. Conceptually, this approach enables room-level localisation based on a network of small antennas. In doing so, it helps museums that suffer from hyper congestion manage visitor flows as too many people in the same space can be detrimental to the quality of the social and cultural experience.

At the Louvre, researchers analysed 24452 visitors' sequential movements, the spatial layout, and the relationship between them using anonymised data collected through noninvasive Bluetooth sensors. Findings show that the visiting styles of short-stay and long-stay visitors are not as significantly different as expected. Both types of visitors tend to visit a similar number of key locations in the museum, while the longer-stay visitors tend to do so more time extensively.

At the Galleria Borghese (Italy), an accurate method for visitor tracking was implemented by considering a dataset made of 900 individual beacons Received Signal Strength Indicator (RSSI) readings and in a scenario where the density of antennas is relatively low. They combined an ensemble of simple localisers, trained based on ground truth, with an encoding of the museum topology in terms of a total-coloured graph. This turned the localisation problem into a cascade process, from large to small scales, in space and in time.

Wireless antennas, by helping in profiling personas, can support psychological wellbeing in terms of satisfaction, the development of competencies for active citizenship - especially regarding digital competencies - and emotional engagement - especially regarding interest and desire to learn.

These systems are sustainable for museums, being economically viable and well accepted by visitors. A free application can be installed on the smartphone and serve as a beacon.

References

Balzotti, C., Briani, M., Corbetta, A., Cristiani, E., Minozzi, M., Natalini, R., Suriano, S., Toschi, F. (2018). Forecasting Visitors' behaviour in Crowded Museums. *Proceedings from the 9th International Conference on Pedestrian and Evacuation Dynamics* (PED2018) Lund, Sweden – August 21-23. https://www.researchgate.net/publication/345093375_Forecasting_Visitors'_behaviour_in_Crowded_Museums

Yoshimura, Y., Sobolevsky, S., Ratti, C., Girardin, F., Carrascal, J. P., Blat, J., & Sinatra, R. (2014). An Analysis of Visitors' Behavior in the Louvre Museum: A Study Using Bluetooth Data. *Environment and Planning B: Planning and Design*, 41(6), 1113–1131. https://arxiv.org/ftp/arxiv/papers/1605/1605.02227.pdf

1.5 Virtual Museums

In the case studies under review, by using a virtual platform that simulates the museum visit, virtual museums improve learning and self-learning; increase the students' participation; support their academic development; foster learning motivation and emotional connection to the museum collection.

For instance, a case study conducted in Malaysia developed a virtual museum and tested it with 404 people interested in Thai culture. The findings demonstrate that virtual museums improved learning and self-learning of the participants. Another case study conducted in Turkey investigated the use of virtual museums in a digital learning environment, which was praised because it is accessible. The results of their study showed that virtual museums increased the knowledge of 7th grade children in the subject of history and geography but also played an important role in the occupational development, as they were asked to draw the reflections of the virtual visits on their occupation development. A research from Ecuador developed a virtual museum based on the national curriculum, which pursued different learning strategies with specific goals such as personal and social development, discovery of natural and cultural environment and expression and communication. The results from the focus groups showed that the virtual museum was deemed to be a fun and innovative experience that helped teachers reach their goals.

Virtual museums seem to be suitable for regional museums that focus on the tradition and culture of the local area.

Virtual Museums can improve psycho-physical wellbeing in terms of self-identity, accessibility and inclusion; develop competencies for active citizenship such as creativity, communication; and foster emotional engagement regarding desire to learn, participation and motivation.

Due to the outbreak of the Covid, virtual museums are now widespread. They can be created with free online platforms (such as Arstep) or museums can call on digital experts that will recreate and customize their virtual museums. The costs of the latter option are higher.

References

Atthasongkhro, J., Kanchanachaya, N., Nitjarunkul, N., Auksornnit, V., Tammachart, J. (2022). The Effect Of Using Virtual Reality Museum For Improving Learning Of The Users Of The Hall Of Southern Thai Culture, Princess Galyani Vadhana Institute Of Cultural Studies, Prince Of Songkla University. *BiblioMed*, 21(1), pp. 82-98. https://www.ilkogretim-online.org/fulltext/218-1644995975.pdf

Elbay, S. (2021). Distance education experiences of middle school 7th grade students in the Turkey during covid-19 pandemic: virtual museum example. Turkish Online Journal of Distance Education-TOJDE, 23(1). https://eric.ed.gov/?id=EJ1329801

Jadán-Guerrero, J., Mendoza, M., Acosta-Vargas, P., Nunes, I. (2022). Digital Learning Experiences in virtual Museums. In Isabel L. Nunes (Eds.), *Human Factors and Systems Interaction*. AHFE (2022) *International Conference. AHFE Open Access, 52. AHFE International, USA.* http://doi.org/10.54941/ahfe1002174

1.6 Physical visits systems (Ipad on wheels)

Physical visit systems such as Ipad on wheels, also known as telepresence robots, are adopted in museums and galleries to make heritage accessible remotely, explore unreachable cultural areas but also to function as a flexible museum guide on site. For instance, a preliminary explanation of a case study that will be conducted in Racconigi Castlein Italy discussed the use of a telepresence robot designed as a tool to explore inaccessible areas of the heritage site. Another EU project called "TOURBOT - Interactive Museum Tele-presence Through Robotic Avatars" focused on the benefits of such a system, such as providing remote access, personalised visits and facilitating the viewing of the collection for people with special needs. A case study conducted in Massachusetts investigated the use of a telepresence robot in an art gallery created for this specific research. Four patients in wheelchairs of a rehabilitation centre visited the gallery from the facility, firstly alone and in the second visit they interacted with a person they previously met. The research studied the easiness of the navigation and the quality of the interaction.

Physical visits systems enhance psycho-physical wellbeing facilitating inclusion and accessibility. The negative sides of physical visits systems are that visitors might be afraid to use it as they do not feel confident enough to command a robot remotely, the interface is often not successful in terms of usability and costs are high, ranging from 4.499 (Double) € to 5.900 (Fernarbeiter) €.

References

Bagherzadhalimi, A., Di Maria, E. (2017). Design considerations for mobile robotic telepresence in museums- A report on the pilot users feedbacks. *Advances in Robotics, Mechatronics and Circuits.* *https://silo.tips/download/design-considerations-for-mobile-robotic-telepresence-in-museums-a-report-on-the*

Lupetti, M. L., Germak, C., Giuliano, L. (2015). Robots and Cultural Heritage: New Museum Experiences. *Electronic Visualisation and the Arts (EVA 2015) (EVA) 7-9 july 2015.* https://revistas.ucp.pt/index.php/jsta/article/view/7244

Trahanias, P. E., Argyros, A. A., Tsakiris, D. P., Cremers, A. B. (2000). TOURBOT-Interactive Museum Telepresence Through Robotic Avatars Project Presentation and Prospects. Proceedings of the 9th Int. WWW Conf., Culture Track, Amsterdam, Netherlands, May 15-19, 2000. https://www.academia.edu/17162559/TOURBOT_Interactive_Museum_Tele_presence_Through_Robotic_Atavars_Project_Presentation_and_Prospects

Tsui, K. M., Dalphond, J. M., Brooks, D. J., Medvedev, M. S., McCann, E., Allspaw, J., Kontak, D., Yanco, H. A. (2015). Accessible Human-Robot Interaction for Telepresence Robots: A Case Study *Paladyn, J. Behav. Robot.* 6, pp. 1–29. https://doi.org/10.1515/pjbr-2015-0001

1.7 Indoor GPS tracking systems

Indoor GPS tracking systems are a network of devices that locate people or objects. To collect and provide this information, different devices are used, such as smartphones, WIKI, bluetooth antennas and bluetooth beacons. This technology is useful to track routes in specific environments. In the museum context, this technology is used to track the visitors' paths and thus understand their experience. Furthermore, Indoor GPS tracking is also used to assist visitors in finding their way around the building, as researchers argue that paper maps are not always helpful as they do not provide recognizable landmarks. A negative aspect of indoor GPS tracking systems is that indoor positioning with GPS is not as precise as outdoor positioning. A case study conducted at the Victoria and Albert Museum investigated the possibility to help visitors navigating four key providers of wide-scale hybrid positioning services were analysed: Google, Navizon, Skyhook and Wigle. The results showed that Wigle's service was the most accurate and Google's service the least.

Regarding indoor GPS tracking systems, there is no relevant research that investigates its use in terms of psycho-physical wellbeing, developing competencies for active citizenship and emotional engagement.

Costs for GPS tracking systems vary depending on the accuracy. The buying costs for an entry level system are around 100 €, while for middle-level they rise up to 600 €.

References

Rains, T., Barros, J. (2011). Wayfinding and visitor tracking in museums: accuracy assessments of hybrid positioning services. *Conference: International Symposium on Spatio-Temporal Analysis and Data Mining.* https://www.researchgate.net/publication/291835739_Wayfinding_and_visitor_tracking_in_museums_accuracy_assessments_of_hybrid_positioning_services

1.8 A.I. - Robot guide interaction

A robot guide is a robot that navigates the museum space or other ambiances and provides visitors with explanations. Some robots are designed with GUI, RFD tags and or speech and face recognition technologies. In a case study conducted in a science museum in Japan a robot is used to identify individuals, to estimate the exhibit at which visitors are looking at and approach them proactively. Through behaviour observations and interviews, the researchers collected the impression of 226 visitors. 24% of the visitors preferred the robot guide, affirming that it was more enjoyable, interactive, more accurate, free from errors, fatigue and they did not feel obliged to listen to it. Researchers analysed the behaviour and impression of second time visitors and they praised the capability of the robot to handle repeated interactions. This research demonstrated that robot systems are generally accepted by visitors. Another case study conducted in the Osaka Museum in Japan investigated how to improve the interaction between a robot guide in a museum and the visitors by designing more human-like body movements and associating visitors to RFID tags. Data from questionnaires reported that the majority of visitors found the robot guide interesting, friendly and effective; low levels of anxiety for interaction and anxiety for future robots were registered.

The drawbacks emerged in the first case study were that visitors deemed robots to not be as flexible as human guides, they do not recognize social cues and are more used to interacting with individuals rather than with larger groups.
Artificial Intelligence (A.I.) robots can improve psycho-physical wellbeing in terms of levels of anxiety; increase competencies for active citizenship such as connection; and foster emotional engagement inspiring a feeling of belonging.
Robots in museums are still a novelty in the field of museum mediation and education also due to their high cost. Their expense can vary from 8.000 € to 20.000-30.000 €, although it is intended to use mass production to reduce the cost to 2.000 € in the future.

References

Iio, T., Satake, S., Kanda, T. et al. (2020). Human-Like Guide Robot that Proactively Explains Exhibits. *Int J of Soc Robotics* 12, pp. 549–566. https://doi.org/10.1007/s12369-019-00587-y
Shiomi, M., Kanda, T., Ishiguro, H., Hagita, N. (2007). Interactive Humanoid Robots for a Science Museum. *IEEE Intelligent Systems*, 22(2), pp. 25-32. https://ieeexplore.ieee.org/document/4136855

1.9 Chatbots

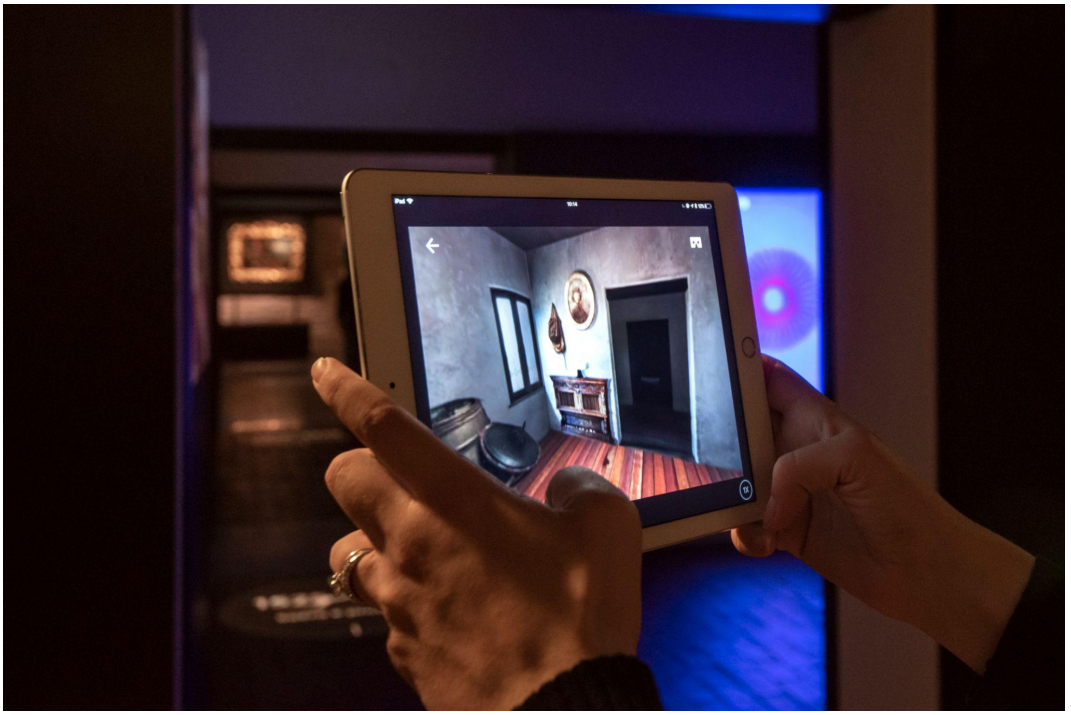
Chatbots are used in museums to create more meaningful experiences by encompassing individuals' diverse motivations and needs.
As a case study conducted in Case Museo in Milano showed, chatbots are very effective with a teenage public. The chatbot was tested with 80 teenage students, 66% of which found it a useful learning tool, especially if it was used with another student or in a small group. In particular, students preferred using the chatbot in small groups, thus collaboration within the team and positive competition with others were created.
At the National Museum of Korea, three different types of chatbots were developed. They were tested with 34 people and findings showed that the chatbot using an historical figure as interlocutor was more effective in terms of engagement and emotional connection, while the docent chat model and the Q&A model were preferred in terms of acquiring knowledge and education.
From the research conducted by Boiano and colleagues, it emerged that chatbots can improve competencies for active citizenship such as connection and collaboration. Participants of the trial, teenage students, were encouraged to interact together with the chatbot and collaborate to solve together the riddles proposed (Boiano & Gaia, 2017).
Chatbots are a very widespread tool. Their popularity makes this technology quite affordable, as some chatbots models are free. To achieve more engaging and refined results, costs will increase: the monthly fee you pay may range from 15 € to 1,000 € circa. Costs will get higher when relying on a chatbot in-house.

References

Boiano, S., Borda, A., Gaia, G., et al. Chatbots and New Audience Opportunities for Museums and Heritage Organisations. *Electronic Visualisation and the Arts (EVA)*, 9 - 13 July 2018. https://www.scienceopen.com/hosted-document?doi=10.14236/ewic/EVA2018.33
Boiano, S., Gaia, G. (2017) 5 Tips for Involving Teenagers in Your Museum Using a Chatbot. Invisible Studio, 27 June 2017. https://medium.com/@invisiblestudio/5-tips-for-involving-teenagers-in-your-museum-using-a-chatbot-bf88ff3ad568.

Noh, Y. G., Hong, J. H. (2021). Designing Reenacted Chatbots to Enhance Museum Experience. *Appl. Sci.*, 11, 7420. https://www.researchgate.net/publication/353861001_Designing_Reenacted_Chatbots_to_Enhance_Museum_Experience

2. Digital tools to enhance contextual or multimedia information of pieces of art



2.1 QR Code

Quick Response (QR) code technologies are used to connect collections with data that can deepen their meaning; improve emotional engagement by enhancing the exploration experience with museum specimens; foster the learning process by making information easily accessible and linkable.

In Chile, to investigate visitors' engagement, the effects of QR codes versus traditional display screens for providing information about the exhibits have been compared by involving 200 participants in a public garden. They also compared one-way QR codes with two-way QR codes as different methods for delivering information by experimenting with 260 college students at a university campus hall.

Another research, based on museum specimens at the Lee Kong Chain School of Medicine (Singapore), shows QR codes effectively integrate medical students' learning and enhance their exploration of the available resources and of the museum itself. According to the 32 respondents, QR codes are useful for the revision of study materials and independent learning.

Furthermore, as shown by the Emotional Mapping of Museum Augmented Places (EMMAP) format, QR codes can be used together with other technologies to create a ubiquitous learning environment and involve participants emotionally. EMMAP was tested at the Archaeological Museum "Giuseppe Moretti" with 115 13- to 16-year-old students,10 students of the Academy of Fine Arts and a group of 20 adults.

Despite these positive examples, it has been noted that visitors often do not engage with QR codes, even though their adoption in museums is increasing. For this reason, research at Nottingham Lakeside Arts gallery involved 28 participants, from young adults to senior citizens, to study the application of visual markers that can be designed to be meaningful and created by visitors. Findings show visitors appreciate the use of the aesthetic markers and engage with them at physical placement, aesthetic content and digital content levels. These three different levels need to be considered when designing such visiting systems to ensure they are mutually supporting in shaping the experience.

NaviLens is an innovative technology formed by colourful multidimensional QR codes, that helps make culture accessible to all audiences and change the way users relate to museums. The museum can use NaviLens to signpost the tour, rooms, showcases and pieces and allow users to get an enriched and accessible experience. Visually impaired people can find their way around and help them guide through the museum. The NaviLens codes mark the spaces, inform the user of where they are and what is in where they are and what is around them, and help them to reach any signposted element with absolute precision. For other users, the app NaviLens Go provides detailed and extended information about the elements and also offers a guidance aid employing arrows in magnified reality superimposed on the mobile screen that will show you at any moment where to go to reach your chosen destination.

QR codes can promote psychological wellbeing in terms of satisfaction, develop competencies for active citizenship - especially concerning communication, creativity and digital competencies - and foster emotional engagement - especially in terms of motivation, interest and participation. QR codes are a cost-effective way of delivering digital information. They have numerous advantages over barcodes, including their small size, superior security mechanisms, increased complexity and quantity of information, and low implementation cost. Online, there are many different tools to create free QR codes, such as the QR code generator retrievable at https://www.the-qrcode-generator.com/it/ or https://goqr.me/ or https://www.flowcode.com/.

References

Ali, S., Koleva, B., Bedwell, B., Benford, S. (2018). Deepening Visitor Engagement with Museum Exhibits through Hand-crafted Visual Markers. *Proceedings of the 2018 Designing Interactive Systems Conference* (DIS '18). Association for Computing Machinery, New York, NY, USA, 523–534. https://www.researchgate.net/publication/325704696_Deepening_Visitor_Engagement_with_Museum_Exhibits_through_Hand-crafted_Visual_Markers

Guazzaroni, G. (2013). Emotional mapping of the archaeologist game. *Computers in Human Behavior*, 29(2), pp. 335-344. https://www.sciencedirect.com/science/article/pii/S0747563212001586

Mogali, S. R., Vallabhajosyula, R., Ng, C. H., Lim, D., Ang, E. T., Abrahams, P. (2019). Scan and Learn: Quick Response Code Enabled Museum for Mobile Learning of Anatomy and Pathology. *Anatomical sciences education*, 12(6), pp. 664–672. https://doi.org/10.1002/ase.1848

Pérez-Sanagustín, M., Parra, D., Verdugo, R., García-Galleguillos, G., Nussbaum, M. (2016) Using QR codes to increase user engagement in museum-like spaces. *Computers in Human Behavior*, Volume 60, pp. 73-85, ISSN 0747-5632. https://doi.org/10.1016/j.chb.2016.02.012

De Miquel Santed, L., Baeza Albaladejo, R., & Fernández Azorín, T. (2022, January). Nuevo lenguaje, nuevas herramientas, nuevas experiencias: la visita virtual y las etiquetas Navilens en el Museo Arqueológico de Murcia. In CIMED21-I Congreso internacional de museos y estrategias digitales (pp. 421-435). Editorial Universitat Politècnica de València.

2.2 NFC TAGS

The Near Field Communication (NFC) technology is a short-range, high-frequency wireless communication technology that enables data exchange between devices. In our case the physical assets and the unique data that are embedded in the NFC chip. This technology is used to help visitors recognise objects in the form of multimedia information (text, images, audio, video, AR, etc.) by scanning the NFC tags near the object. It triggers a greater educational context about the objects concerned and offers a wide range of possibilities, whether museum professionals want to add context and extra information to visitor experiences or seek a nifty way of reaching out to communities who may never come to their establishment. Overall, NFC technology serves a twofold goal: 1) to improve visitors' interaction and overall experience of the exhibit; 2) to give museum management valuable information about visitor activity so that it is possible to profile personas.
In Munchen, researchers developed a prototype of a mobile museum guide based on the physical interaction with a dynamic NFC display, consisting of a grid of NFC tags and a projected GUI. Its usability and interaction with a dynamic NFC display were evaluated by asking 10 individuals to browse a predefined tour to look up specific information and compose a new tour.
Within the ASPIRE Project, an open-source middleware for museology was presented, researchers used external devices such as media renderers to create an augmented reality environment around visitors to improve interaction and the overall experience of the exhibit while giving museum management valuable information about visitor activity.
In Indonesia, scholars developed a mobile app to help visitors recognise objects in the form of multimedia information. It uses Android Studio, which displays multimedia information by scanning the NFC tags near the object. They also developed a web application for museum administrators, through which they obtain statistical data for future museum development.
The NFC technology can help psychological wellbeing in terms of satisfaction, develop competencies for active citizenship - especially regarding digital competencies - and foster emotional engagement - especially regarding interest and desire to learn.
The NFC technology is mature and meeting the mass market in many application domains. It is extremely powerful despite offering great value for money. It is only really limited by the creativity of museum professionals in how it can be deployed to enhance the offering of modern public-facing institutions.

References

Bihler, P., Imhoff, P., Cremers, A. B. (2011). SmartGuide – A Smartphone Museum Guide with Ultrasound Control. *The 8th International Conference on Mobile Web Information Systems (MobiWIS).* https://doi.org/10.1016/j.procs.2011.07.076
Rudametkin, W., Touseau, L., Perisanidi, M., Gomez, A., Donsez, D. NFCMuseum: an Open-Source Middleware for Augmenting Museum Exhibits. Opensource: https://lig-membres.imag.fr/donsez/pub/publi/icps08-nfcmuseum.pdf
Setiabudi, D. J., Wiguno, R. C., Palit, H. N. (2017). Near Field Communication Technology in Delivering Information in Museums. *International Conference on Soft Computing, Intelligent System and Information Technology.* http://repository.petra.ac.id/18484/3/Conference-repo_18484.pdf

2.3 Informative or Multimedia Totem

Multimedia totems are communication technology tools that increase knowledge during a museum tour. Their content is designed according to the museum's message and can be implemented through different technologies and for different objectives.
For instance, totems can assist in profiling visitors and propose the most suitable exhibition path for their satisfaction. Experimentation with six adult participants at the Modern Art Museum "Palazzo Buonaccorsi" (Macerata) used an interactive touch screen totem, which implemented a USB camera and exploited a Convolutional Neural Network to perform facial coding to measure visitors' emotions and estimate their age and gender. Based on the detected level of emotional valence, the system associated visitors with a profile and suggested a selection of works of art, following a specific itinerary. Findings showed that the proposed system can create an interactive and emotional link with the visitors, positively influencing their mood.
Totems can also engage different age groups with the expressive potential of AR in terms of performance as it makes it possible to transform any surface into a dynamic display. It is the case of the valorisation of the block NXLVI of the north frieze of the Parthenon, where the human sensory perception was enhanced by information generally manipulated and electronically channelled that would otherwise not be perceived by the five senses.
In comparison to traditional applications, totems can eliminate the need for indoor positioning technologies, which are unfeasible in many scenarios as they can only be employed when museum items are physically distinguishable, as demonstrated by the painted wooden ceiling of the Sala Magna of Palazzo Chiaramonte in Palermo. It was developed as an accurate and effective system that visitors could use to automatically get a description of the scenes they were interested in by pointing their smartphones to a multimedia totem.
As "containers" for different content and technologies with various objectives, multimedia totems can promote psychological wellbeing in terms of satisfaction, develop competencies for active citizenship - especially concerning activity, critical thinking and digital competencies - and foster emotional engagement - especially in terms of desire to learn, motivation, interest and participation.
Multimedia totems are now fairly common products in museums. Their price can vary approximately from €1000 to €5000.

References

Altieri, A., Ceccacci, S., Giraldi, L., Leopardi, A., Mengoni, M., Talipu, A. (2021). Affective Guide for Museum: A System to Suggest Museum Paths Based on Visitors' Emotions. In M. Antona & C. Stephanidis. (Eds.), *Universal Access in Human-Computer Interaction. Design Methods and User Experience.* HCII 2021. Lecture Notes in Computer Science, 12768. Springer: Cham.
https://www.researchgate.net/publication/352957675_Affective_Guide_for_Museum_A_System_to_Suggest_Museum_Paths_Based_on_Visitors'_Emotions
Cirafici, A., Maniello, D., Amoretti, V. (2015). The magnificent adventure of a "fragment". Block nxlvi parthenon north frieze in augmented reality. *SCIRES-IT,* 5(2), pp. 129-142.
https://www.digitalmeetsculture.net/article/the-magnificent-adventure-of-a-fragment-block-nxlvi-parthenon-north-frieze-in-augmented-reality/?upm_export=pdf
Concone, F., Giaconia, R., Re, G.L., & Morana, M. (2021). A Smart Assistant for Visual Recognition of Painted Scenes. *IUI Workshops*.
https://www.semanticscholar.org/paper/A-Smart-Assistant-for-Visual-Recognition-of-Painted-Concone-Giaconia/ad955519c5493805199273d90cffbcd795fdb3a7

2.4 Augmented Reality (AR)

AR is adopted in museum contexts to enhance the discovery-based learning process and promote emotional engagement. It is especially useful to overcome the inaccessibility and untouchability of objects.

The Mobile Augmented Reality Touring System (M.A.R.T.S) demonstrated that AR can transform the visitor learning experience and direct visitors' attention by emphasising and superimposing. This system was tested on 17 adult visitors of the Bayonne's Museum of Art and History. The evaluation considered both quantitative and qualitative data. Quantitative data correspond to the number of correct answers to questions about the exhibits. Qualitative data were collected to estimate the learning experience. Questions relating to the GLO model as a basis were used. To complete the questionnaire, three questions were asked among those most used in AR literature. Another research employed Kolb's Experiential Learning Cycle as a theoretical base. A museum in the UK was used as a single case study: experiments and three focus groups were conducted with 19 schoolchildren and data were analysed using thematic analysis. This study revealed three new themes specific to schoolchildren's experiential learning experiences with AR in museums including: (1) integrating AR could further enhance knowledge acquisition, (2) schoolchildren were able to identify their preferred learning style, and (3) schoolchildren are motivated to continue learning with AR in museums.

AR can promote psychological wellbeing in terms of satisfaction, develop competencies for active citizenship - especially in terms of activity, critical thinking and digital competencies - and foster emotional engagement - especially in terms of desire to learn, motivation and sense of vitality.

Overall AR is increasingly widespread in museums and often combined with other mobile technologies. For those who want to try AR development for the first time, the best options are free open-source AR Software Development Kits. Paid SDKs in most cases offer several pricing plans, depending on the user's needs. Building a complex app with large, dynamic content will likely require a commercial licence. Unity is perhaps the best software as it is free, relatively easy to use and the most popular for developing computer games.

References

Ghouaiel, N., Garbaya, S., Cieutat, J.-M., & Jessel, J.-P. (2017). Mobile Augmented Reality in Museums: Towards Enhancing Visitor's Learning Experience. *International Journal of Virtual Reality*, 17(1), pp. 21–31. https://doi.org/10.20870/IJVR.2017.17.1.2885

Moorhouse, N., Dieck, T., Jung, T. (2019) An experiential view to children learning in museums with Augmented Reality. *Museum Management and Curatorship*, 34(4), pp. 402-418. https://www.semanticscholar.org/paper/An-experiential-view-to-children-learning-in-with-Moorhouse-Dieck/5a4d9892b8826ff711e237e5826b40a724caa3fa

2.5 Blockchain (NFTs)

The use of blockchain in museums is varied. It can be adopted to protect data and ensure secure monitoring and management of the museum; it can be used as a form of revenue by licensing objects conserved at the museum via the creation of NFTs; it can foster the exchange of collections between museums thus promoting cultural heritage and dissemination of knowledge and it can be used to explore the concept of guardianship by allowing museum visitors to add a new layer of interpretation on the objects.

Since the 1990s, museums have been deploying digital technologies to engage with visitors as a means of providing new means of education, information, social awareness and crowd engagement. At the same time, these technologies allow museums to gather statistics and useful

data. Blockchain technology can assure data integrity, preventing unauthorised users from retrieving information. Other researches focus on the way museums can exploit the authorization mechanism based on the blockchain technology related to a museum's digital rights to realise the economic benefits. A case study conducted at National Museums Liverpool in the UK with 7 participants demonstrated that by letting visitors contribute to the construction of the knowledge about that artefact, the object and the museum experience become more valuable, as value is formed through social relations and discussion. A case study investigated the benefits of information exchange on the blockchain between the Bejing Planetarium and the Bejing Museum of Natural History. The analysis results show that the regulation scheme based on the exchange blockchain system of the museum's digital collections proves to be feasible, with security and expansibility.

The argument against blockchain is that the created digital files are perceived as less valuable than physical objects because it is difficult to form exclusivity around them, as the research from Liverpool stated.

Blockchain fosters the development of competencies for active citizenship, especially the skills of collaboration, communication and critical thinking.

The exploration of the use of blockchain technology in museums is at an early stage. To create a blockchain application the costs vary from 5.000 to 200.000 €.

References

Liddel, F. (2021). Building Shared Guardianship through Blockchain Technology and Digital Museum Objects. *Museum & Society*, 19(2) https://journals.le.ac.uk/ojs1/index.php/mas/article/view/3495

Siountri, K., Skondras, E., Vergados, D. D. (2019). Towards a Smart Museum using BIM, IoT, Blockchain and Advanced Digital Technologies. *Proceedings of the 3rd International Conference on Vision, Image and Signal Processing (ICVISP 2019).* Association for Computing Machinery, New York, NY, USA, Article 23, pp. 1–6. https://www.researchgate.net/publication/341645677_Towards_a_Smart_Museum_using_BIM_IoT_Blockchain_and_Advanced_Digital_Technologies

Zhao, L., Zhang, J., Jing, H., Wu, J., Huang, Y. (2022). A Blockchain-Based Cryptographic Interaction Method of Digital Museum Collections. *SSRN*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4129431

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

3. Digital tools to contextualise simulations of real pieces of art

3.1 Virtual Reality (VR)

Most current research is about integrating VR into the traditional frame of a museum to enable a deeper and more meaningful understanding of the displayed artworks. The Hönnunarsafn Íslands Museum of Design and Applied Art designed and developed an interactive VR exhibit that could showcase museum artefacts not physically on display. After the identification of best practices for developing interactive exhibits and surveying the interests of museum visitors, researchers developed a user-friendly VR exhibit prototype. After analysing visitors' feedback and the post-interaction prototype results, recommendations were drafted for how the museum could improve and maintain the prototype.

Another study analysed Viking VR, an exhibit through which viewers can experience the sights and sounds of a 9th Century Viking encampment. Created as part of a major museum exhibition, the experience was developed by an interdisciplinary team. This case study also approaches the design of authentic, informative and compelling VR experiences for Cultural Heritage contexts and issues surrounding interaction design for the long-term deployment of VR experiences in museums, discussing the challenges of VR authoring workflows for interdisciplinary teams.

Other scholars drew from the four realms of the experience economy and assumed absorptive experiences influence immersive experiences, overall museum VR tour experience, and intention to visit a museum. The results supported all the hypotheses and showed the efficacy of the model they developed.

Virtual Reality (VR) appears to promote psychological wellbeing in terms of satisfaction, develop competencies for active citizenship - especially in terms of activity, communication, critical

thinking and digital competencies - and foster emotional engagement - especially in terms of desire to learn, motivation, sense of vitality, participation and interest.
Building a complex app with large, dynamic content requires a commercial licence, proficient skills and time. To get started, the free plan of Frame VR and Unity are among the most valid resources. Online it is possible to find out other free tools, each of them better suited to specific purposes, such as, for instance, SketchUp for architects.

References

Gatto, C., D'Errico, G., Paladini, G.I., De Paolis, L.T. (2021). Virtual Reality in Italian Museums: A Brief Discussion. L. T. De Paolis, P. Arpaia & P. Bourdot. (Eds.), *Augmented Reality, Virtual Reality, and Computer Graphics. AVR 2021. Lecture Notes in Computer Science*, 12980. Springer: Cham.
https://www.semanticscholar.org/paper/A-Smart-Assistant-for-Visual-Recognition-of-Painted-Concone-Giaconia/ad955519c5493805199273d90cffbcd795fdb3a7

Gobira, P., de Oliveria Silva, E. (2019). About reality: Relations between museums and virtual reality. *Virtual Creativity,* 9(1-2), pp. 63-72 https://doi.org/10.1386/vcr_00005_1

Lowry, E., Jackson, N., Herchenroder L., Guy L. (2019). *Archiving a museum with an interactive exhibit. A report to detail the process of creating an interactive, virtual reality exhibit for the Hönnunarsafn Íslands Museum of Design and Applied Art.*October 8, 2019.
https://web.wpi.edu/Pubs/E-project/Available/E-project-100819-143110/unrestricted/Museum_FinalPresentation.pdf

Lee, H., Hyungsoo Jung, T., tom Dieck, M.C., Chung, N. (2020). Experiencing immersive virtual reality in museums. *Information & Management*, 57(5). https://doi.org/10.1016/j.im.2019.103229

Schofield, G. P., Beale, G., Beale, N. E. (2018). Viking VR: Designing a Virtual Reality Experience for a Museum. *DIS 2018 - Proceedings of the 2018 Designing Interactive Systems Conference. ACM DIS Conference on Designing Interactive Systems*, 09-13 Jun 2018 ACM, HKG, pp. 805-816.
https://eprints.whiterose.ac.uk/129158/1/vikingvr_preprint.pdf

3.2 Wall projectors

Wall projections in museums consist of displaying digital images or videos on surfaces of the museum's walls, pavements, exhibition panels or screens. Wall projectors in museums are not only used to project digital products but also to show enlarged images and descriptions of the exhibited materials, and to shed light on exhibits in a way that hidden details are highlighted.
In a case study at the National Museum of Japanese History, images of the kimono were projected by the projector onto a whiteboard held in a hand. The goal was to enhance the understanding of certain exhibits by providing visitors with a more integrated guidance system that would diminish the distraction factors that may occur when reading informative panels and would increase their engagement. The projections consisted of descriptions of the exhibited materials, simulation of colour changes of the materials under different illuminants and indications of areas where the materials have important reference information to understand them. The installation was evaluated through a visitor survey which showed that 48% of the visitors deemed it to be effective and strongly effective.
Another case study conducted by the University of Hamburg suggested using this technology to create an augmented reality but not as immersive as VR so that objects and the museum environment can still play a fundamental role in the learning experience. The findings of this research showed that visitors felt a stronger connection with the real exhibit and enjoyed not being isolated from their companions. In a case study conducted in the Immigration Museum Melbourne, the observations of museum staff workers guarding a projection installation pointed out some

issues that this technology might bring. For instance, it is better to not project sensitive content, for example, religious images, as visitors might feel uncomfortable walking on them. Moreover, in the case of interactive projections, it is fundamental to guarantee real-time feedback.
Wall projectors can develop competencies for active citizenship such as connection and create emotional engagement regarding participation.
The expenses include not only the projectors, but also the support device and video players. Costs can range from little more than 100 € to 2.600 €, varying based on the quality of the projectors, the projection distance and the brightness of the site.

References

Miyata, K., Takiguchi, T., Nakaguchi, T., Tsumura, N., Miyake, Y. (2008). An application of projection imaging systems for museum exhibitions. *Proc. SPIE 6807, Color Imaging XIII: Processing, Hardcopy, and Applications*, 68070L. https://doi.org/10.1117/12.765785
Schettino, S. (2016) Successful Strategies for Dealing With New Technology in Museums: A Case Study of Immersive Technology at the Immigration Museum, Melbourne. *Museum International*, 68:1-2, 130-135. https://ur.art1lib.com/book/64550966/b9b96e
Schmidt, S., Steinicke, F. (2017). A Projection-Based Augmented Reality Setup for Blended Museum Experiences. *ICAT-EGVE*, pp. 1–2. https://diglib.eg.org/bitstream/handle/10.2312/egve20171366/005-006.pdf

3.3 3D holographic projections

3D holographic projections are one of the areas of greatest interest to make artworks accessible to a mass audience. They are more commonly used in digital art museums, digital art exhibitions, and other digital media art applications to engage visitors and those audiences who cannot be present.
In Italy, it was developed a "Virtual holographic" display, i.e. stereoscopic virtual reality system, that can replicate the behaviour of a real showcase for exhibitions. Evaluation of the system through an experimental session with 20 users showed a good user perceptual experience compared to a standard motion parallax technique and simulated image of an optical profiler. Despite their increasing adoption in museums, existing applications are commonly built upon a single technology, focusing on visualisation, motion or verbal interaction (e.g., high-resolution projections, gesture interfaces, chatbots). This aspect limits their potential, since museums are highly heterogeneous in terms of visitors' profiles and interests, requiring multi-channel, customizable interaction modalities. On these premises, it has been developed and evaluated as an artificial intelligence-powered, interactive holographic stand aimed at describing Leonardo Da Vinci's art. This system provides the users with accurate 3D representations of Leonardo's machines, which can be interactively manipulated through a touchless user interface. It can also dialogue with the users in natural language about Leonardo's art while keeping the context of conversation and interactions. Experimentation was aimed to assess how 164 users of different ages and interests perceive, understand and explore cultural objects through this technology.
3D holographic projections appear to foster emotional engagement, especially in terms of desire to learn and interest.
There are many 3D holographic projectors available on the market for most different needs. Depending on their characteristics, they can have prices ranging approximately from €40 to €4000.

References

Caggianese, G., De Pietro, G., Esposito, M., Gallo, L., Minutolo, A., Neroni, P. (2020). Discovering Leonardo with artificial intelligence and holograms: A user study. *Pattern Recognition Letters*, 131, , pp. 361-367. https://doi.org/10.1016/j.patrec.2020.01.006

Chessa, M., Garibotti, M., Rossi, V., Novellino, A., Solari, F. (2015). A virtual holographic display case for museum installations. *7th International Conference on Intelligent Technologies for Interactive Entertainment* (INTETAIN), 2015, pp. 69-73. https://ieeexplore.ieee.org/document/7325488

Pietroni, E., D'Annibale, E., Pagano, A. (2019). The Use of Holographic Showcases Inside the Museum's Context. Towards an Advanced Museology Creating a Dramaturgy Around the Exhibited Objects. https://www.mpm.edu/sites/default/files/files%20and%20dox/C&R/Hologrant%20White%20Paper.pdf

3.4 3D Printings

3D printing has seen a recent diffusion in the field of Cultural Heritage. Being used for different purposes, such as study, analysis, conservation or access to museum exhibitions, 3D-printed replicas need to undergo a process of validation also in terms of metrical precision and accuracy. The Laboratory of Photogrammetry of the Iuav University of Venice has started collaborations with Italian museums for the digital acquisition and physical reproduction of objects of historical and artistic interest. Researchers analysed the metric characteristics of the printed model in relation to the original data and optimised the process that from the survey leads to the physical representation of objects selected according to the needs of specific exhibitions and targets.
In terms of physical and cultural accessibility, 3D printing can help provide a more meaningful experience. The ARTLAB+ program in Washington, D.C., and the Parachute Factory in New Mexico are examples of maker spaces focusing on hands-on activities with cutting-edge technologies including 3D printers for a variety of users. A special exhibit on 3D technology at the British Museum and Samsung Digital Discovery Center enabled visitors to recreate museum pieces with computer-aided design technology, 3D pens and 3D printing.
3D printings can promote psychological wellbeing through inclusion and accessibility, develop competencies for active citizenship, especially in terms of activity, and foster emotional engagement through interest, desire to learn, sense of vitality, participation and motivation.
Most Entry Level and Hobbyist 3D printers are priced from €300 to €500, while some can be as expensive as €1500. The higher-end 3D printers, such as Enthusiast 3D printers and Professional 3D printers are priced anywhere from €1,500 to €20,000, depending on the printer's capabilities. An alternative could be ordering online using services like those offered by Xometry.

References

Ballarin, M., Balletti, C., and Vernier, P. (2018). Replicas in cultural heritage: 3D printing and the museum experience. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XLII-2, 55–62. https://www.researchgate.net/publication/325471477_REPLICAS_IN_CULTURAL_HERITAGE_3D_PRINTING_AND_THE_MUSEUM_EXPERIENCE

Hancock, M. (2016). Museums and 3D Printing: More Than a Workshop Novelty, Connecting to Collections and the Classroom. *Bulletin of the Association for Information Science and Technology*, 42(1), pp. 32-35. https://www.semanticscholar.org/paper/Museums-and-3D-Printing%3A-More-Than-a-Workshop-to-Hancock/f0d0577d10886964820dc443ffe1a65f6a79306c

Hess, M., & Robson, S. (2013). Re-engineering Watt: A case study and best practice recommendations for 3the D colour laser scans and 3D printing in museum artefact documentation. https://www.researchgate.net/publication/237045069_Re-engineering_Watt_A_case_study_and_best_practice_recommendations_for_3D_colour_laser_scans_and_3D_printing_in_museum_artefact_documentation

Wilson, P.F., Stott,Jason, J., Warnett, M., Attridge, A., Smith, M. P., Williams, M. A. (2018). Evaluation of Touchable 3D-Printed Replicas. *Museums. Curator. The Museum Journal*, 60(4), pp. 445-465. http://wrap.warwick.ac.uk/100926/1/WRAP-Evaluation-of-touchable-3D-printed-replicas-Wilson-2018.pdf
Wilson, P. F., Stott, J., Warnett, J. M., Attridge, A., Smith, M. P., & Williams, M. A. (2018). Museum visitor preference for the physical properties of 3D printed replicas. *Journal of Cultural Heritage*, 32(Complete), 176–185. https://ora.ox.ac.uk/catalog/uuid:91ecc74e-f1d2-450c-bf11-0b62fe56da5b/download_file?file_format=application%2Fpdf&safe_filename=Wilson%2Bet%2Bal%2BJCH.pdf

3.5 Video Mapping

Video mapping is a form of augmented reality that integrates a digital dimension with the tangible one. It usually consists of a projection of digital images and videos on a site, monument or building. It aims to enhance certain features of the sites and interaction among visitors.
A case study conducted in the Graethem Chapel in Belgium consisted in evaluating the video mapping installations through user experience surveys and observations. From the findings it emerged that the setup investigated encouraged participants to take on different roles, thus enhancing the levels of interaction and collaboration between them.
Video mapping can enhance competencies for active citizenship such as collaboration: in the case study cited above, participants could control the projector and steer it towards the direction where other visitors were looking, creating a collaborative experience.
Video mapping costs are similar to video projections costs (100 €- 2.600 €). In addition, the costs of the content projected must be calculated.

References

Nofal, E., Stevens, R., Coomans, T., Vande Moere, A. (2018). Communicating the Spatiotemporal Transformation of Architectural Heritage via an In-Situ Projection Mapping Installation. *Digital Applications in Archaeology and Cultural Heritage*.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

4. Digital methodologies to enhance learning processes

4.1 Digital Storytelling

Digital Storytelling (DST) can revolutionise the way we engage with cultural heritage. It has been widely recognised as an important direction for attracting and satisfying the audiences (especially "digital natives") of museums and other cultural heritage sites as well as for supporting teaching and learning at every level of education. This approach has been investigated in various research projects because of its potential to promote wellbeing. It can stimulate emotional engagement, make difficult content culturally accessible and rememberable, thus promoting a sense of cultural belonging, and develop transversal and digital skills. Still, its adoption outside research remains relatively limited due to the challenges inherent in its creation, which do not concern the technology in itself.

A Greek research group developed the web-based Narrative Storyboard Editor (NSE) and the Narrative Mobile Player (NMP) app, which assist the creative process and promote research on different aspects of the application of mobile digital storytelling in cultural heritage settings. The NSE was presented to its potential authors in a variety of Workshops and Events and it was used by different cultural heritage institutions to author digital storytelling experiences for their sites. In all cases, researchers recorded the author's feedback on the NSE as well as visitor feedback on the NMP, including how visitors perceived the produced experiences.

The Cultural Heritage Experiences through Socio-personal interactions and Storytelling (CHESS) project aimed to research, implement and evaluate an innovative conceptual and technological framework that will enable both the experiencing of personalised interactive stories for visitors of cultural sites and the authoring of narrative structures by the cultural content experts. The

evaluation involved 28 museum visitors and staff at the Acropolis Museum. While curators considered CHESS a promising system for individualising museum messages, visitors felt interested and keen on re-visiting, even those with no previous interest in it.
DST can promote psychological wellbeing in terms of satisfaction, inclusion and accessibility, develop competencies for active citizenship - especially in terms of digital competencies - and foster emotional engagement - especially in terms of desire to learn and sense of vitality.
DST could be incorporated into any museum narrative through every imaginable format museum professionals deem feasible. Online, there is a great variety of free and licensed software that, also combined with other technologies, can help produce DST. It is possible to choose those apps better fitted to specific goals and the materials one's working with. DST is no longer technologically challenging. However, when designing DST, one must weigh the costs of resources and strive to make a balance between many parameters dependent on the museum's objectives and constraints.

References

Katifori, A. et al. (2014). CHESS: Personalized Storytelling Experiences in Museums. In A. Mitchell, C. Fernández-Vara, D. Thue. (Eds.), *Interactive Storytelling*. ICIDS 2014. Lecture Notes in Computer Science, 8832. Springer: Cham. https://www.researchgate.net/publication/290082841_CHESS_Personalized_Storytelling_Experiences_in_Museums

Pujol, L., Roussou, M., Poulo, S., Balet, O., Vayanou, M. and Ioannidis, Y. (2012). personalising Interactive Digital Storytelling in Archaeological Museums: the CHESS Project. *40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology* (CAA), Southampton, UK, 26-29 March 2012, pp. 77-90. https://www.madgik.di.uoa.gr/sites/default/files/2018-06/caa2012_paper_final.pdf

Robin, B. R. (2016). The Power of Digital Storytelling to Support Teaching and Learning. *Digital Education Review*. 30. https://files.eric.ed.gov/fulltext/EJ1125504.pdf

Vrettakis, E., Kourtis, V., Katifori, A., Karvounis, M., Lougiakis, C., Ioannidis, Y. (2019). Narralive – Creating and experiencing mobile digital storytelling in cultural heritage. *Digital Applications in Archaeology and Cultural Heritage*, 15. https://www.researchgate.net/publication/337729466_Narralive_--_Creating_and_experiencing_mobile_digital_storytelling_in_cultural_heritage

4.2 Hands-on (tactile reproductions)

Hands-on in museums has proved to promote emotional engagement and learning for every kind of visitor as it ensures accessibility and inclusivity.
At Tinkering Lab, a permanent exhibit at Chicago Children's Museum, studies were conducted on 61 families with 6- to 8-year-old children to determine the impact of partially completed hands-on exhibits in science museums on children's motivation and engagement. The central question was whether partially completed exhibits are more motivating for children than fully completed or uncompleted exhibits. Findings showed that children preferred partially completed exhibits over uncompleted exhibits. Hands-on activities are feasibly applied to Tinkering. However, the design of exhibits and programs and the nature of children's interactions with adults can determine if and to what extent tinkering engenders participation in engineering practices such as testing and redesign. Researchers and museum practitioners worked together using design-based research methods to develop and test tinkering programs that could best support engineering learning. At the science centre NEMO, a practical application of the Exploratory Behaviour Scale (EBS) was directed at optimising parent guidance to improve preschoolers' exploration of exhibits. Experiment 1, concerning 71 children, investigated which adult coaching style resulted in the highest level of

exploratory behaviour at two exhibits. Experiment 2, concerning 75 children, investigated whether informing parents about an effective way of coaching influenced preschoolers' exploratory behaviour at two exhibits. Findings demonstrated the added value of the EBS in visitor behaviour research: compared to existing global measures of visitor interactivity, the EBS adds information about the quality of the hands-on behaviour.

Hands-on activities can promote psychological wellbeing through inclusion and accessibility, develop competencies for active citizenship - especially in terms of communication, collaboration, critical thinking and creativity - and foster emotional engagement - especially in terms of interest, motivation, desire to learn and sense of vitality.

Hands-on is primarily applied in Science museums. However, it can be adapted to any object.

Costs can vary depending on the materials involved but are generally modest or even null.

References

Makers at School, Educational Robotics and Innovative Learning Environments: Research and Experiences from FabLearn Italy 2019, in the Italian Schools and Beyond. (2021). Svizzera: Springer International Publishing. https://link.springer.com/book/10.1007/978-3-030-77040-2

Caulton, T. (2006). *Hands-On Exhibitions: Managing Interactive Museums and Science Centres*. Regno Unito: Taylor & Francis.

Paris, S. (1996). Children's Motivation to Explore Partially Completed Exhibits in Hands-On Museums. *Contemporary Educational Psychology*, 21, pp. 111-128. https://www.academia.edu/49430308/Childrens_Motivation_to_Explore_Partially_Completed_Exhibits_in_Hands_On_Museums?auto=citations&from=cover_page

Pagano, L. C., Haden, C. A., Uttal, D. H. (2020). Museum program design supports parent-child engineering talk during tinkering and reminiscing. *Journal of Experimental Child Psychology*. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.689425/full

Van Schijndel, T. J. P., Franse, R. K., Raijmakers, M. J. E. (2010). The Exploratory Behavior Scale: Assessing young visitors' hands-on behavior in science museums. *Science Education,* 94(5), pp. 794-809. https://onlinelibrary.wiley.com/doi/pdfdirect/10.1002/sce.20394

4.3 Gamification

Gamification refers to the use of game elements and game-design techniques in non-game contexts. Gamification is widely used in museum contexts for its ability to influence the decision of visitors to attend museums; improve the learning experience; control and direct crowds.

Research conducted in some museums of the Baltic Sea Coast, the Lithuanian Sea Museum in Klaipeda, Malmö Museums and the National Marine Fisheries Research Institute's Gdynia Aquarium, investigated the use of gamification to influence visitors. According to their findings, visitors stated that the possibility of using a game app at the museum influenced their decision to visit the cultural site. In a case study in Indonesia, it was found that gamification in museums improves learning in museums since people are motivated by components such as "Quest" and "Achievement" that activate their emotions and curiosity. Furthermore, gamification gives a clear vision of what to learn during the visit.

In a further study at the Yo-Chang Art Museum in Taiwan in 2020, the visitor experience of two AR paths was analysed: one with a gamification setting, and the other with a free navigation modality. Results showed that visitors who used the gamification AR experience followed a more precise route, thus indicating that gamification can be useful to control the flow of crowds.

In a research conducted at the Silversmithing Museum in Greece, researchers pointed out that the benefit of gamification is that it reduces the costs of hardware as it can be experienced on smartphones and tablets.
Gamification can foster emotional engagement regarding increasing motivation.
The general costs are around 5.000 - 20.000 €, for 2D mobile games, but can reach up to 50.00 - 200.000 when the development is more complex and the game has more functionalities.

References

Bieszk-Stolorz, B., Dmytrów, K., Eglinskiene, J., Marx, S., Miluniec, A., Muszyńska, K., Niedoszytko, G., Podlesińska, W., Rostoványi, A. V., Swacha, J., Vilsholm, R. L., Vurzer, S. (2021). Impact of the availability of gamified e-guides on museum visit intention. *Procedia Computer Science*, 192, pp. 4358-4366. https://doi.org/10.1016/j.procs.2021.09.212
Lee, C.I. (2022). Benefit Analysis of Gamified Augmented Reality Navigation System. *Appl. Sci.*, 12, 2969. https://doi.org/10.3390/app12062969
Paliokas, I., Patenidis, A. T., Mitsopoulou, E. E., Tsita, C., Pehlivanides, G., Karyati, E., Tsafaras, S., et al. (2020). A Gamified Augmented Reality Application for Digital Heritage and Tourism. *Applied Sciences*, 10(21), 7868. MDPI AG. http://dx.doi.org/10.3390/app10217868

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

5. Sensory-based Technologies

5.1 Heighten Sensory Awareness

Heighten Sensory Awareness is a technology that uses a Kinect motion-sensing controller, projectors, and projection mapping software to display video and images within a space with which a user can interact. The users can engage with the installation by moving, waving their hands or touching the projection. It is used in museums to enhance the levels of engagement and participation among the crowds.

A case study from the University of Hamburg and the University of South Australia, analysed user interaction, user guidance and user collaboration of spatial augmented reality setups of 40 people. Regarding the collaboration between two users, findings showed that this kind of experience fostered communication and collaboration between visitors, even when the pair was composed of two strangers.

Heighten sensory awareness can improve competencies for active citizenship such as communication and collaboration.

Regarding the costs, they are similar to video projectors on walls (100 € to 2.600 €), to which the costs of the Kinect system must be added. They range from 50 € to 4000 € (Microsoft Azure Kinect).

References

Schmidt, S., Steinicke, F., Irlitti, A., Thomas, B. H. (2018). Floor-Projected Guidance Cues for Collaborative Exploration of Spatial Augmented Reality Setups. *Proceedings of the 2018 ACM International Conference on Interactive Surfaces and Spaces (ISS '18)*. Association for Computing Machinery, New York, NY, USA, 279–289. https://basilic.informatik.uni-hamburg.de/Publications/2018/SITS18/floorUI.pdf

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

5.2 Gesture based technology

Gesture based interaction allows users to control a technical system with gestures, body, hands and arms. It is adopted in museum contexts to augment the interactivity of the museum experience

A case study conducted at the Baba Nyonya Heritage Museum in Malaysia investigated the effectiveness of technological affordances (mixed and augmented reality techniques and gesture recognition) upon the experiences of children and their families, focusing on how the installation initiated engagement, discussion and reflection. From the pre-test and post-test surveys, user observations and video analyses, it emerged that a highly interactive and multisensory experience fosters engagement, reflection and discussion and provides learning gains.

Another research that took place at the Museum of Nature and Human Activities in Japan showed similar results, where it was demonstrated by the word association method that 19 students of elementary school acquired more knowledge in an immersive learning environment using their body movements.

Gesture based technology can foster competencies for active citizenship such as critical thinking and promote emotional engagement by encouraging participation.

The costs are similar to the heightened sensory awareness devices.

References

Hai, H., Lo, W. H., Ng, H. H., Brailsford, T., & O'Malley, C. (2018). Enhancing reflective learning experiences in museums through interactive installations. *13th International Conference of the Learning Sciences (ICLS) 2018*, pp. 776-783. https://uwe-repository.worktribe.com/output/867382/enhancing-reflective-learning-experiences-in-museums-through-interactive-installations

Tokuoka, M., Mizoguchi, Egusa, R., Inagaki, S., Kusunoki, F. (2018). Effectiveness of a Cooperative Museum Learning Support System based on Multiple People Body Movements. *International Journal of Education and Research*, 6. https://www.ijern.com/journal/2018/November-2018/16.pdf

5.3 Haptics

Haptic technology is used in museum contexts to communicate tactile information to museum visitors; create greater engagement; provide new means of education; store existing historic artworks for future generations; enable visitors to interact with digital replicas of their collection;

A case study conducted at the Monash University studied if haptic devices can enhance the interaction between museum visitors and objects. 50 people from the University Campus responded to a survey, which showed that haptics successfully enable greater interaction with the sculptures in question.

Research led at the National Museum of Scotland and Orkney Archaeological Museum also evaluated a haptic installation adopted in museums by investigating the subjective opinions of visitors, the degree of engagement and the phenomenological experience. By gathering verbal and written feedback, observing the public's behaviour and carrying out questionnaires, it was shown that visitors agreed that the combination of visual and haptic cues gave a much better sense of the object, and increased the sense of authenticity in comparison to just viewing it in its case.

Another case study that took place at Tate Britain in the UK studied the perception of haptic technology in the context of a multisensory exhibition. The research team collected 2500 questionnaire-based feedback from 2500 visitors and conducted 50 interviews. Findings shed light on the subjective experiences and reported positive impressions. In particular, the

multi-sensoriality of the experience was described by visitors to allow stronger emotional reactions, such as empathy.

According to the research conducted in Australia, haptic devices have been in existence for a considerable amount of time. However, public exposure to haptic devices has been very limited, with its implementation being mainly restricted to research environments. Content requirement, functional requirement, comfort, experience and resistance are important factors to be considered when developing and implementing the wearable AR application in the museum and art gallery contexts.

Concerning their availability, there is an array of programmable haptic devices that are commercially available, such as Phantom Omni by Sensable Technologies.

Haptics can foster emotional engagement by enhancing participation.

The price for this technology is around 19.577,35 euros.

References

Butler, M., Neave, P. (2008). Object appreciation through haptic interaction. In R. Atkinson, & C. McBeath (Eds.), *Proceedings of the 25th Annual Conference of the Australian Society for Computers in Learning in Tertiary Education* (ascilite Melbourne 2008, pp. 133 - 141. Deakin University. https://ascilite.org/conferences/melbourne08/procs/butler-m.pdf

Dima, M., Hurcombe, L., Wright, M. (2014). Touching the Past: Haptic Augmented Reality for Museum Artefacts. In R. Shumaker, S. Lackey (Eds.), Virtual, Augmented and Mixed Reality. *Applications of Virtual and Augmented Reality. VAMR 2014. Lecture Notes in Computer Science*, 8526. Springer, Cham. https://link.springer.com/content/pdf/10.1007/978-3-319-07464-1_1.pdf

Vi, C. T., Ablart, D., Gatti, E., Velasco, C., Obrist, M. (2017). Not just seeing, but also feeling art: Mid-air haptic experiences integrated in a multisensory art exhibition. *International Journal of Human-Computer Studies*, 108, pp. 1-14. https://doi.org/10.1016/j.ijhcs.2017.06.004

5.4 Smell artefacts

Nowadays, more than just presenting artefacts, museums are creating more participatory experiences by incorporating multisensory effects, with even smells to immerse visitors in a more realistic and complete experience. In fact, while smell may be the forgotten sense, many museums are now starting to make use of its unusual psychological properties.

Visual stimuli activate different parts of our brain than smells, and when the two modalities are artfully combined, interesting effects can be achieved. One example of an art installation with an olfactory component was a gallery in which all the walls were covered by used $1 bills (Feldmann, Guggenheim Museum New York, 2011). A reviewer of this exhibition remarked that “what sounds on paper like a conceptual stunt or a riff on Warholian materialism becomes overpoweringly physical in person, thanks to the smell of the used bills” (Rosenberg, 2011). A similar effect has been created by filling a gallery with Christmas trees that were discarded after the holidays (Klara Lidén, S.A.D. [in Klara Lidén: Pretty Vacant at Reena Spaulings Fine Art], New York, 2012). In both of these cases, visual and olfactory stimuli complement each other, with the visual stimuli activating thought and the olfactory stimuli eliciting emotions. Seeing 100,000 one-dollar bills pinned to the wall of a gallery results in thoughts about materialism and the role of money in the art world. Smelling a room full of money, however, is an unexpected and overpowering emotional experience. Similarly, seeing a forest of dead pines and firs in a small gallery makes the visitor think about the wastefulness of cutting down a tree to use it for a few days as decoration and then discard it. Smelling a forest of Christmas trees, on the other hand, elicits positive emotions in many who have happy childhood

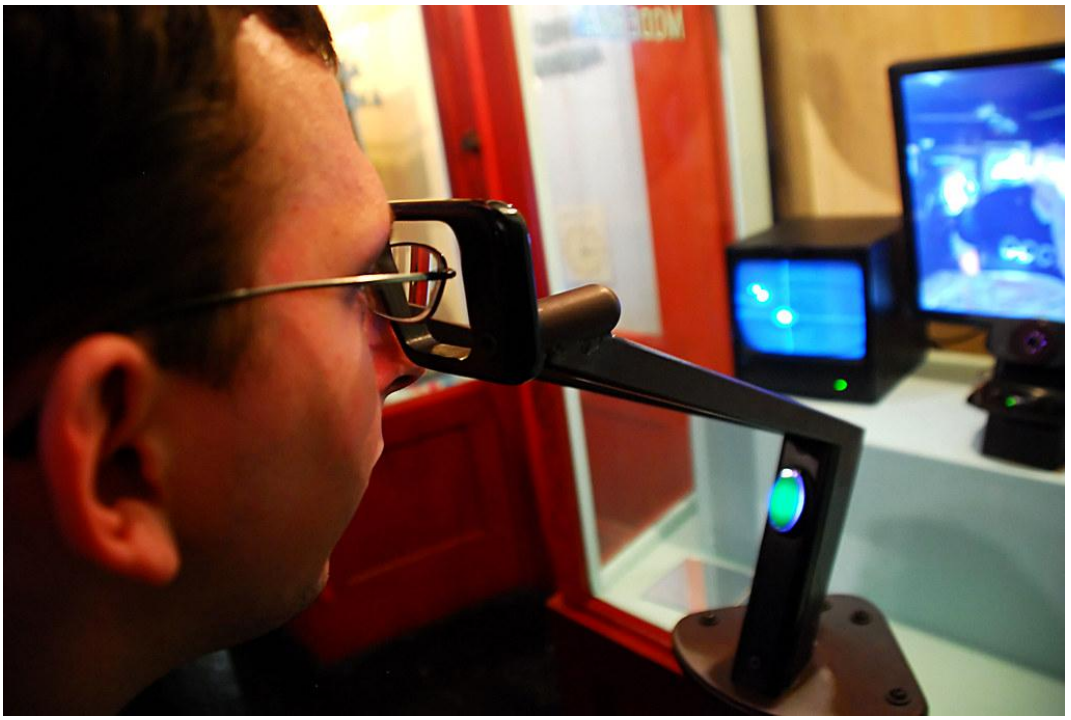
holiday memories that are triggered by the smell. (Triggering vivid childhood memories is another process at which smells are better than sights; see Herz and Cupchik, 1995.)
Although promising interesting results in terms of emotional engagement, olfactory exhibitions should take into consideration the individuals who sit with the works during the museum experience as placing scent in a gallery can generate intolerant reactions even when relatively benign. A second challenge for scent art is to develop a conceptual framework. The limited vocabulary for smell gives the impression that it is mainly a phenomenological experience, one that lies before cultural conditioning or beyond the ability of language to encompass.

References

Levent, N. & Pascual-Leone, A. (Ed.) (2014). The Multisensory Museum Cross-Disciplinary Perspectives on Touch, Sound, Smell, Memory, and Space. Lanham: Rowman & Littlefield.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

6. Technologies for studying visitors' emotions and preferences



6.1 A.I. for identifying visitors' behaviours and preferences

Artificial Intelligence (A.I.) comes in handy when personalising museum contents, which is pivotal for enhancing the visitor experience. However, most museums do not offer this kind of service yet, and even fewer museums focus on modelling visitor engagement to foster learning processes. Research on 85 visitors of interactive science museum exhibits used multimodal sensor data—including eye gaze, facial expression, posture, and interaction log data— captured during visitor interactions to induce predictive models of visitor dwell time. They also investigated machine learning techniques (random forest, support vector machine, Lasso regression, gradient boosting trees, and multi-layer perceptron) to induce multimodal predictive models of visitor engagement. Results from a series of ablation experiments suggested that incorporating additional modalities into predictive models of visitor engagement improves model accuracy. In addition, the models showed improved predictive performance over time, demonstrating that increasingly accurate predictions of visitor dwell time can be achieved as more evidence becomes available from visitor interactions with interactive science museum exhibits.

Another research was based on a questionnaire study. It was administered to 105 visitors of a Science and Technology Centre and examined the minimal features needed to identify visitor personas. Findings showed museum visitors can be clustered by their visit motivation and perceived success factors; these clusters are found to correspond both with Falk's visitor categorisation and a prior classification of exploration styles.

A.I., by helping in profiling personas, appears to support psychological wellbeing in terms of satisfaction and self-esteem, the development of competencies for active citizenship - especially

regarding critical thinking and digital competencies - and emotional engagement - especially regarding interest, desire to learn and motivation.
Albeit promising results, A.I. is still little used for creating personas because of the costs and competencies needed.

References

Almeshari, M., Dowell, J., Nyhan, J. (2021). Museum Mobile Guide Preferences of Different Visitor Personas. *J. Comput. Cult. Herit.* 14, 1, Article 9 (February 2021), 13 pages. https://discovery.ucl.ac.uk/id/eprint/10115352/1/Museum%20Mobile%20Guide%20Preferences%20for%20Different%20Visitor%20Personas%20FINAL.pdf

Almeshari, M., Dowell, J., Nyhan, J. (2019). Using Personas to Model Museum Visitors. *Adjunct Publication of the 27th Conference on User Modeling, Adaptation and Personalization* (UMAP'19 Adjunct). Association for Computing Machinery, New York, NY, USA, 401–405. https://core.ac.uk/download/pdf/200748699.pdf

Emerson, A., Henderson, N., Rowe, J., Min, W., Lee, S., Minogue, J., Lester, J. (2020). Early Prediction of Visitor Engagement in Science Museums with Multimodal Learning Analytics. *Proceedings of the 2020 International Conference on Multimodal Interaction* (ICMI '20). Association for Computing Machinery, New York, NY, USA, 107–116. https://www.intellimedia.ncsu.edu/wp-content/uploads/emerson-icmi-2020.pdf

Trejo, K., Angulo, C., Satoh, S. Bono, M. (2018). Towards robots reasoning about group behavior of museum visitors: Leader detection and group tracking. *Journal of Ambient Intelligence and Smart Environments*, 10(1), pp. 3-19, 2018. https://www.researchgate.net/publication/322609811_Towards_robots_reasoning_about_group_behavior_of_museum_visitors_Leader_detection_and_group_tracking

Zancanaro, M., Kuflik, T., Boger, Z., Goren-Bar, D., Goldwasser, D. (2007). Analyzing Museum Visitors' Behavior Patterns. In Conati, C., McCoy, K., Paliouras, G. (Eds.), *User Modeling* 2007. UM 2007. Lecture Notes in Computer Science, 4511. Springer, Berlin, Heidelberg. https://www.researchgate.net/publication/221260782_Analyzing_Museum_Visitors'_Behavior_Patterns

6.2 Software Mezzini

Technology can help make on-site visits to museums much more satisfactory, by assisting visitors during their experience. To this aim, it is necessary to monitor the active user and acquire information about their behaviour. This information can be used for various purposes: to provide visitors with personalised services such as recommendations of points of interest and additional textual and multimedia content; to analyse the individual and social behaviour of visitors; to improve artwork arrangement; to optimise visitors' flow.
The University of Roma Tre proposed a novel approach to indoor tracking, which can represent a promising and non-expensive solution for some critical issues. It relies on low-cost equipment (i.e., simple badges and off-the-shelf RGB cameras) and harnesses one of the most recent deep neural networks (i.e., Faster R-CNN) for detecting specific objects in an image or a video sequence with high accuracy. The accuracy of this system was tested through experimentation in a real scenario, the "Exhibition of Fake Art" at Roma Tre University.
This software, by helping in profiling personas, appears to support psychological wellbeing in terms of satisfaction, the development of competencies for active citizenship - especially regarding critical thinking and digital competencies - and emotional engagement - especially regarding interest and desire to learn.
This solution is sustainable for museums as it uses low-cost equipment (i.e., off-the-shelf RGB cameras) and requires the visitor to wear a simple badge, thus being non-intrusive.

References

Cepeda-Pacheco, J.C., Domingo, M.C. (2022). Deep learning and Internet of Things for tourist attraction recommendations in smart cities. *Neural Comput & Applic,* 34, pp. 7691–7709. https://upcommons.upc.edu/bitstream/handle/2117/365733/Cepeda-Pacheco-Domingo2022_Article_DeepLearningAndInternetOfThing.pdf?sequence=1

Ferrato, A., Limongelli, C., Mezzini, M., & Sansonetti, G. (2022). Using Deep Learning for Collecting Data about Museum Visitor Behavior. *Applied Sciences*, 12(2), 533. MDPI AG. https://upcommons.upc.edu/bitstream/handle/2117/365733/Cepeda-Pacheco-Domingo2022_Article_DeepLearningAndInternetOfThing.pdf?sequence=1

6.3 Eye-tracking for mapping emotional responses during museum visits

Eye-tracking can be used in museums to map the visitors' emotional responses and understand how they watch museum objects. On these premises and by adopting different technologies, it is possible to design: 1) explanations that consider the consumption pattern; 2) descriptions in augmented reality, superimposed on the gaze, that enhance the visitor's emotional engagement; 3) individualised explanations.

Research at the Museum of Science and Industry, Chicago (MSI–Chicago) on 31 participants used traditional survey-based measures partnered with innovative mobile eye-tracking technology. It demonstrated how the conjunction of methods enriches insights into momentary, ephemeral emotions experienced in naturalistic settings. Mobile eye-tracking technology can investigate guests' experiences of awe in museums by analysing visitors' visual attention and examining associations between visual attention and survey responses. It is therefore possible to highlight relationships between how guests attend to features within an exhibit space (e.g., signage) and their feelings of awe. The concurrent use of both methods sheds new light on exhibit design, and it appears to help work in transdisciplinary multimethod teams to move scientific knowledge and application forward.

At the Salzburg Museum, researchers investigated how to create effective visitor learning experiences in contemporary museums through an analysis of visual attention. The findings reveal that the physical context greatly influences the museum learning experience, and show significant differences in attention and engagement levels across the exhibition's elements.

eye-tracking can help detect psychological wellbeing in terms of satisfaction, develop competencies for active citizenship - especially regarding activity and awareness - and foster emotional engagement - especially regarding interest and desire to learn.

The cost of one piece of eye-tracking hardware is high and can vary by tens of thousands of euros, resulting in different levels of precision and sampling rate. When choosing eye-tracking hardware, it is fundamental to primarily consider the research objectives, even though the budget is an important aspect: investing in a non-optimal eye tracker could end up costing you later in wasted time, resources, and grant funding. Furthermore, measuring equipment must be calibrated, and precise distances must be respected to collect reliable data, which is not always easy in museum spaces.

References

Krogh-Jespersen, S., Quinn, K.A., Krenzer, W.L.D., Nguyen, C., Greenslit, J., Price, C.A. (2020). Exploring the awe-some: Mobile eye-tracking insights into awe in a science museum. *PLoS ONE* 15(9). https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0239204&type=printable

Rainoldi, M., Yu, CE., Neuhofer, B. (2020). The Museum Learning Experience Through the Visitors' Eyes: An eye-tracking Exploration of the Physical Context. Rainoldi, M., Jooss, M. (Eds.), *eye-tracking in Tourism. Tourism on the Verge*. Springer: Cham.
https://www.researchgate.net/publication/344484357_The_Museum_Learning_Experience_Through_the_Visitors'_Eyes_An_Eye_Tracking_Exploration_of_the_Physical_Context

6.4 Smartwatch for mapping emotional responses during museum visits

Smartwatch-based systems can facilitate museum gallery exploration, improve engagement, strike a balance between personal and public interactions, and map emotional responses as they can detect emotions directly as opposed to questionnaires.
Studies show that the user's strong impression is related to the decrease in heart rate. In Japan, a system that obtains the user's impressions by detecting their heart rate was developed, using a smartwatch and mapping the detected impression on a map using Android API. The system was implemented with an Android smartwatch, an Android tablet, and Google Map API. The evaluation was carried out by showing the emotional arousal image to a subject on the Toyohashi University of Technology campus. Findings confirmed that the user impressed places were mapped, and showed a problem with the accuracy of the heart rate data.
Another research group created FieldGuide. Its design and implementation were evaluated with twelve visitors in a natural history museum, proving that smartwatches can fit into a multi-display museum environment.
Research at the Ningbo Museum (China) took the perspective of 503 consumers' behaviour, focusing on the visit cycle (prospective, active, and reflective phases), based on the theoretical foundations of the customer journey process model. Findings from the experimentation showed that smart technologies influence the customer journey at all three phases, the most significant being at the prospective and active phases, without neglecting the reflective one.
Smartwatches can help detect psychological wellbeing in terms of satisfaction and emotional engagement - especially regarding interest and sense of vitality.
Smartwatches are the most widely adopted wearables after the activity tracker. Generally, they provide almost the same functionality as a smartphone. However, most smartwatches' energy efficiency is still challenging without the gateway node due to the small form factor. Their cost can range approximately from €20 to €500.

References

Banerjee, A., Robert, R., Horn, M. S. (2018). FieldGuide: Smartwatches in a Multi-display Museum Environment. *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* (CHI EA '18). Association for Computing Machinery, New York, NY, USA, Paper LBW061, 1–6. https://doi.org/10.1145/3170427.3188694
Okabe, A., Ohmura, R. (2016). Poster: Towards Creating User's Impression Map with Wearable Sensors. *Proceedings of the 14th Annual International Conference on Mobile Systems, Applications, and Services Companion* (MobiSys '16 Companion). Association for Computing Machinery, New York, NY, USA, 67.
https://doi.org/10.1145/2938559.2948824
Shen, S., Sotiriadis, M., & Zhang, Y. (2020). The Influence of Smart Technologies on Customer Journey in Tourist Attractions within the Smart Tourism Management Framework. *Sustainability*, 12(10), 4157.
http://dx.doi.org/10.3390/su12104157

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

6.5 Making visitors visual artefacts - selfies

Selfies, the art of taking pictures of oneself, emerged in the early 21st century in the media and online culture, supported by communication and information technology with internet networks. Since the application of two-sided cameras on cell phone products, selfies have become a global phenomenon. It became a common practice even in museums, where it is used to better understand visitors' behaviour, establish a closer connection to the exhibited objects, provoke emotions, co-create value and promote the museum content.

An investigation conducted in South Korea used computer vision to analyse visitors' Instagram pictures tracked by those related to the exhibition. The results showed that studying these images and selfies is a useful tool for the museum to gain insights into the visitors' behaviour, how they interact with objects and what is valued by visitors.

In a research conducted at the National Gallery of Victoria, the activity of selfie-taking was analysed through in field observations, netnography method and semi-structured interviews. Findings showed that selfie-taking corresponds to co-creational consumer behaviour driven by engagement with the objects displayed and the museum environment. The exhibits facilitate close connections with the visitors, provoking emotions and allowing them to share their experiences on social media platforms. The products they post are the results of this process of co-creation of value and meaning, that democratises the museum environment.

Selfies can improve psycho-physical wellbeing in terms of self-identity; foster competencies for active citizenship such as creativity; and foster emotional engagement promoting participation. This technology is costless as visitors use their devices and post on social media open and available to everyone.

References

Piancatelli, C., Massi, M., & Vocino, A. (2021). #artoninstagram: Engaging with art in the era of the selfie. *International Journal of Market Research*, 63(2), pp. 134–160. https://www.researchgate.net/publication/344212482_artoninstagram_Engaging_with_Art_in_the_Era_of_the_Selfie

Rhee, B. A., Pianzola, F., Choi, J., Hyung, W., Hwang, J. (2022). Visual content analysis of visitors' engagement with an instagrammable exhibition. *Museum Management and Curatorship*, pp- 1-15. https://pure.rug.nl/ws/portalfiles/portal/200942332/09647775.2021.pdf

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Possible technological applications to cultural heritage for promoting wellbeing and health

Technologies are never the end result but just tools to convey a message and achieve objectives. Promoting wellbeing, intended as psycho-physical wellbeing, competency in a democratic society, emotional engagement and accessibility, makes it necessary to design a process in which technologies are a resource to achieve the intended goals.
From the literature review conducted, no studies have explicitly stated their intention to investigate ways to promote wellbeing and health in museums through technology. However, these technologies foster, at different levels, learning processes, promote emotional engagement, enhance cultural and physical accessibility, and, in general, aim to improve the user experience. Indeed they are adopted to achieve one or more of these ends.

1. Possible technological applications to promote psycho-physical wellbeing

While all the above-mentioned technologies differently improve the user experience, psycho-physical wellbeing is especially enabled through:

1. Quick Response codes;
2. Augmented Reality;
3. Virtual Reality;
4. Digital Storytelling;
5. Audioguides;
6. Videoguides;
7. Virtual tours;
8. Hands-on (tactile reproductions);
9. 3D printings;
10. Virtual museums;
11. Gamification;
12. Gesture Based Technology;
13. Chatbots.

2. Possible technological applications to promote wellbeing in terms of competencies for active citizenship

Those interested in lifelong learning and fostering active citizenship might usefully integrate these technologies in their research projects as long as their design also includes the development of transversal skills.
Among the above-mentioned technologies, those better suited to promote wellbeing in terms of competencies for active citizenship are listed below:

1. Quick Response codes;
2. Augmented Reality;
3. Virtual Reality;
4. Digital Storytelling;
5. 3D printings;
6. Audioguides;
7. VIdeoguides;
8. Virtual tours;
9. Hands-on activities;
10. Virtual Museums;
11. Blockchain;
12. Wall Projectors;
13. Robot Guide Interaction;
14. Gamification;
15. Heighten Sensory Awareness;
16. Making Visitors Visual Artefacts;
17. Gesture Based Technology;
18. Video Mapping;
19. Haptics;
20. Chatbots.

3. Possible technological applications to promote wellbeing in terms of emotional engagement

The following technologies, even more so when combined with inclusive and collaborative teaching methodologies, could boost emotional engagement:

1. Augmented Reality;
2. Virtual Reality;
3. 3D holographic projections;
4. Digital Storytelling;
5. 3D printings;
6. Audioguides;
7. Videoguides;
8. Virtual tours;
9. Hands-on activities;
10. Physical Visits Systems;
11. Virtual Museums.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2.A2 - "Handbook on the use of technology for inclusive educational activities in museum context"

Results 2 | Activity two	
Title: Handbook on the use of technology for inclusive educational activities in museum context	
Delivery	September 2022
Leader /Co-Leader	Zètema / Università degli Studi di Modena e Reggio Emilia
Review	October 2022

The creation of these resources has been funded by the ERASMUS+ grant program of the European Union under grant no. 2021-1-IT02-KA220-HED-000031991. Neither the European Commission nor the project's national funding agency are responsible for the content or liable for any losses or damage resulting from the use of these resources.

Print

This publication is number PR2.A2 of the strategic collaboration founded by the ERASMUS+ grant program of the European Union under grant no. 2021-1-IT02-KA220-HED-000031991 | **(https://piattaformaintellect.it/portale/index.php/outputs/)**

PDF download

A full PDF version of the text is available and can be downloaded free of charge from the website:

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Mapping the technologies

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
Technologies for per	**Virtual tours** are a useful way to connect with cultural heritage when museums, sites and places of culture are not accessible for the most different reasons. They are also a valuable resource for teaching and learning, helping people to engage with cultural heritage. A 360° immersive video applications for Head Mounted Display (HMD) was developed and tested.	Historical Centre of the city of Rethymno in Crete	Greece	21 local participants familiar with the history of the city	Not available	Yes	A logging mechanism integrated in the Rethymno 360° immersive video application was recording quantitative data during runtime to study each participant's response. Questionnaires were conducted.	https://link.springer.com/article/10.1007/s00779-020-01373-8
	A **virtual museum** has been created in which **3D digital models** of parietal and portable art are exhibited with complementary annotations for each one.	Virtual museum PaleoArt-3D. Facultad de Geografía e Historia (Universidad de Salamanca).	Spain	Any visitor.	Open	Having a 3D printer, autonomously		https://polipapers.upv.es/index.php/var/article/view/17684/15282
	Virtual Museums - virtual platforms that simulate the museum visit. Thet mprove learning and self-learning, increase the students' participation, support their academic development, foster learning motivation and emotional connection to the museum collection.	Adana, Ankara Painting and Sculpture, Ephesus, War of Independence, Troy, Anatolian Civilizations, Gobeklitepe Ruins, Ataturk and Istanbul Toy found on the website of Ministry of Culture and Tourism.	Turkey	14 students from 7th grade.	Available online	Yes	Participants visited the virtual museums and then took part in the evaluation process.	https://eric.ed.gov/?id=EJ1329801
	Virtual Museums - virtual platforms that simulate the museum visit. Thet mprove learning and self-learning, increase the students' participation, support their academic development, foster learning motivation and emotional connection to the museum collection.	"Traveling without leaving the classroom" created by the research group on ArtSteps.	Ecuador	30 children..	Available on Artsteps: https://www.artsteps.com/view/60b05da970224387850a407e?currentUser	Yes	Participants visited the virtual museums and then took part in the evaluation process.	https://www.artsteps.com/view/60b05da970224387850a407e?currentUser ; https://www.researchgate.net/publication/352939889_Digital_Museums_as_Pedagogical_Mediators_in_the_Pandemic_Crisis

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Telepresence (roaming video) - **Telepresence robots** let bedridden art lovers explore museums remotely. A Beam is a roaming video device that could enable people who can't physically visit museums to explore them remotely. While most museums make a big effort to make their spaces accessible to as many people as possible, countless citizens are still unable to visit because of poor health or disabilities. A **roaming video device called Beam** – developed by Suitable Technologies (Suitable Technologies develops systems that **combine mobility and video conferencing**) – could enable people to explore the exhibits in museums and galleries remotely. Beam is a moving telepresence device which can be controlled remotely via desktop. The robot is equipped with a wide angle camera at approximately eye level and another facing the ground, to help the pilot navigate the space. The camera has a 3x zoom, but the developers are looking to expand this to a 10x zoom which will enable users to read labels and experience close-up views of artworks. The Beam also features a screen which displays the face of the user, giving them a visual and potential audio presence at the gallery.	Fine Arts Museum of San Francisco Detroit Institute of Arts Computer History Museum Seattle Art Museum National Museum of Music	United States	People unable to physically displace to and visit museums.	Not available	No	Not available	https://gobe.blue-ocean-robotics.com/beam-to-go be https://www.club-innovation-culture.fr/6-musees-americains-testent-la-telepresence-pour-permettre-au-public-handicape-ou-malade-dexplorer-leurs-galeries/
	IA robots - They navigate the museum space or other ambiances and provide visitors with explanations.	National Museum of Science and Innovation.	Japan	226 visitors.	ASIMO	Yes	Free exploration.	https://link.springer.com/article/10.1007/s12369-019-00587-y#:~:text=We%20developed%20an%20autonomous%20human,speak%2Dand%2Dretreat%20interaction.

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	IA robots - They navigate the museum space or other ambiances and provide visitors with explanations.	Osaka Museum.	Japan	2891 visitors.	Robovie II	Yes	Visitors interacted freely with the robot, some wore RFID tags and some filled a questionnaire.	https://www.researchgate.net/publication/3454456_Interactive_Humanoid_Robots_for_a_Science_Museum
	Chatbots - Chatbots are computer programs that simulate conversations using auditory or textual methods. They are used in museums to create more meaningful experiences by encompassing individuals' diverse motivations and needs and foster collaboration.	National Museum of Korea (but conducted in a laboratory due to Covid).	South Korea	34 museum visitors.	N/A	Yes	Visitors interacted with the chatbot.	https://www.mdpi.com/2076-3417/11/16/7420
	The museum offers **videos and descriptive text** on how to access different sites and buildings of the museum as they are in different parts of the city. Also it describes what to be seen in the museum buildings. The website offers a social skills story, explaining a visit to Reykjavík Art Museum – Kjarvalsstaðir. Open to general public.	Reykjavík City Museum	Iceland	People with ASD.	Open	Autonomously		https://reykjavikcitymuseum.is
	The museum offers **videos and descriptive text** on how to access different sites and buildings of the museum as they are in different parts of the city. Also it describes what to be seen in the museum buildings. The website offers a social skills story, explaining a visit to Reykjavík Art Museum – Kjarvalsstaðir. Not open to general public	Reykjavik Art Museum	Iceland	People with ASD.	Open	autonomously		https://listasafnreykjavikur.is/en

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	APP for Smartphones and Tablets - REALIZASOM (company that develops mobile contents and solutions for visitors' autonomous interpretation in cultural, historical and touristic sites) developed an innovative APP for Smartphone and tablets **with contents accessible to visitors with specific needs** It is the only national museum to provide a **complete and autonomous visit** to its exhibition, in sign language. Under the pilot project "Tesouros ao Alcance de Todos (Treasures at Everyone's Reach)", the National Tile Museum already had audio and video-guides with audio description for visually impaired visitors and sign language for deaf visitors. These informative supports offered users a guided tour through the history of tiles in Portugal, the most significant pieces in the exhibition and the most interesting spaces in the museum. The APP uses the same multi-format contents, which can be accessed directly through the visitors' mobile devices. - Available from the Google Play (Android) and APP Store (iOS); - 33 points of interest; - Duration: 80 minutes; - 2 audio versions with audio description (Portuguese and English); - 2 video versions in sign language (Portuguese sign language and international gesture); - Access by list ordered by floor;- Access by typing a numerical code; - Information in text format; - Possibility of sequential visits;- List of your favourite points of interest; - Sharing content on social networks;- Useful information (introduction, contacts...); - Collection of visitor statistics;- Download by QRCode.	Museu Nacional do Azulejo (National Museum of Artistic Tiles).	Portugal	Visitors with specific needs, especially deaf and auditory impairment.	Open	Yes	30.000 users	https://realizasom.com/pt/projetos/museus/mnazmuseu-nacional-do-azulejo (company website) https://apps.apple.com/pt/app/museu-do-azulejo/id1151355810 (Apple Store)

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Zoom webinar sessions -The Visually Impaired Programme at the National Galleries of Scotland has evolved over the years and now comprises regular, free in-gallery and montly online, audio-resources that support visitors with visual impairments to explore the galleries and collections in their own time. Priority is to make the whole gallery environment more accessible and inclusive. Blind and partially sighted audiences want better diversity and choice about how and when they engage with the galleries and to enjoy the same opportunity that exists for other visitors. In the morning, specialist artists lead a conversational, descriptive tour in the gallery space, that, wherever possible, will include the opportunity to touch artworks. The afternoon is taken up with a practical art-making workshop that offers the chance to explore creative responses to artworks. Online sessions take place via Zoom **through a video call or over the telephone**, making the experience open to those who do not use a computer. In these relaxed meetings one can explore art through visual description and conversation and explore artworks that are not currently on display, discovering hidden stories in the collection, able to zoom in on details in artworks and enlarge smaller objects such as portrait miniatures to make them more accessible to a visually impaired audience. Online sessions started during lockdown as a way to continue making connections through art during a period when the galleries were closed, these sessions connected people across Scotland and beyond. Online sessions have now become a core part of the programme.	National Galleries of Scotland.	United Kingdom	Visually impaired visitors.	Not available	No	Not available	https://www.nationalgalleries.org/learn/visual-impairment

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	From the Barracco Museum website: **Li-Fi**, which stands for **Light Fidelity**, exploits the use of **LED light to transmit data to smartphones or tablets**. The Li-Fi light device plays the role of transmitter, while the mobile device, equipped with a camera, is the receiver. This creates a very high-speed data network with important feature: directionality, because the devices communicate only when illuminated by the light emitted by the light fixture, ensuring a high level of security. The use of this technology in the Barracco Museum has seen the definition and implementation of a short but significant route, consisting of a number of points of interest on the ground and second floors of the Museum, suitably illuminated by Li-Fi spotlights. Thanks to Li-Fi, it is possible to create a flexible and reconfigurable internal geolocation system, which allows visitors to visit the Museum with the support of multimedia content (photos, videos, infographics, etc.) that greatly enriches the visitor experience.	From the Barracco museum website: Museum of Ancient Sculpture Giovanni Barracco. The collection of the Museum, set up in a suggestive sixteenth-century building, consists of about 400 works that testify the Egyptian, Mesopotamian, Phoenician, Cypriot, Greek, Etruscan and Roman figurative cultures,, also offering examples of medieval art. All in one exhibition divided into 9 rooms on three floors. Similar project: Smart@Pompei.	Italy	All visitors, blind, visually impaired.	To Be Srl, DB Ingegneria dell'immagine Srl, Tecno Electric Srl	Partially autonomously. To use the multimedia contents, users have to download the appropriate App (roll up and QR code are availble at the entrance of the museum) and place the own smartphone or tablet under the light of the Li-Fi spotlight.	Not available yet	http://www.museobarracco.it/; https://tobe-srl.it/

Erasmus+
Project n. 2021-1-IT02-KA220-HED-000031991

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	From the Ara Pacis museum website: Audiopen: audio-description, on Audiopen, which guides the blind and visually impaired visitor in the exploration of the drawings in relief and in the knowledge of Doisneau's work. The Audiopen is activated simply by pointing the pen on a code placed on the relief drawing; to listen to the audio story, visitors can use their own earphones or headphones made available by the museum. The Audiopen is free and is issued at the ticket office upon presentation of an identity document. From the Ara Pacis Museum and exhibition **website there is a section dedicated to accessibility** where you can: 1) download the **maps for blind and visually impaired visitors;** 2) obtain all the information about the routes; 3) download the a**udio tracks and pdf texts and insights**; 4) download room texts and chronology; 5) download the calendar of tactile tours; 6) download the calendar of guided tours with LIS interpreter; 7) download the **LIS video of the exhibition**. The device is used in other museums such as the Reggia di Venaria in Turin, the Scrovegni Chapel in Padua, and Notre Dame in Paris.	Summary from the Ara Pacis Museum website: "Robert Doisneau" exhibition (Ara Pacis Museum Augustae 28.05-04.09.2022). The Capitoline Superintendence, in order to increase the inclusiveness of museum spaces and support participation in cultural life, has made available various tools and dedicated tours to promote awareness of the French photographer's work.	Italy	All visitors, blind, visually impaired.	Sycomore	Not autonomously. From the Ara Pacis museum website: To support the visit experience by the blind and visually impaired people, the Ara Pacis Augustae Museum, in collaboration with the Omero State Tactile Museum of Ancona and with Zètema, made available to visitors: six relief drawings positioned along the exhibition path, in correspondence with the original photographs; an audio description, on Audiopen activated by pointing the pen on a code placed on the relief drawing; to listen to the audio story, visitor can use their own earphones or headphones made available by the museum.	Not available yet	https://www.arapacis.it/it/infopage/robert-doisneau-accessibilit-mostra; https://www.arapacis.it/sites/default/files/f_immagine/Ara%20Pacis_Robert%20Doisneau_traccia%20audio%2005.mp3

Erasmus+
Project n. 2021-1-IT02-KA220-HED-000031991

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Mobile APP - A **Dementia awareness programme**, that will include **a range of training, app packages, and activities to enable caregivers to support person-centred care** for people living with dementia. The **My House of Memories app** has pictures of objects from across the decades, which are brought to life with sound, music and descriptions, and provide an easy-to-use way to help people living with dementia explore things that resonate with them. Visitors can browse the objects, which include everyday things such as cinema tickets, a Singer sewing machine and a 10 shilling note. Visitors can save favourite objects to a digital memory tree, digital memory box or timeline. With themes including school, work, leisure and maritime, there's a world of objects to explore. The My House of Memories app now has a 'My Memories' feature, which enables users to upload their own photos to share precious personal memories with the people they care for living with dementia.	National Museum of Liverpool.	United Kingdom	Caretakers of people with dementia.	Open	Yes	Not available	https://www.liverpoolmuseums.org.uk/house-of-memories Download the My House of Memories app iTunes store - https://apps.apple.com/gb/app/my-house-of-memories/id847763460?ign-mpt=uo%3D4 Google play - https://play.google.com/store/apps/details?id=com.nml.myhouseofmemories

Erasmus+
Project n. 2021-1-IT02-KA220-HED-000031991

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Ciencia signada', an **extension of the Dictionary of the Spanish Sign Language** (Dilse). A new translation into Spanish of 250 terms about museums, science and research to sign language.	Museo Nacional de Ciencias Naturales de Madrid (MNCN-CSIC) and Fundación CNSE.	Spain	Users with deaf hearing impairment.	Open, Creative Commons Attribution-Non Commercial-ShareAlike 3.0 Unported.	Autonomously		https://www.servimedia.es/noticias/mncn-fundacion-cnse-traducen-lengua-signos-espanola-250-terminos-sobre-museos-ciencia-e-investigacion/3459274
	A **platform with a 3D system** allows people with mobilityreduced visit the Punic Wall of Cartagena	Interpretation Center of the Punic Wall of Cartagena and the Univeridad Politécnica de Cartagena.	Spain	Motor disabled users.	Exclusive use	Autonomously		https://www.murcia.com/cartagena/noticias/2022/03/21-una-plataforma-con-sistema-3d-permite-a-las-personas-con-movilidad-reducida-visitar-la-muralla-punic.asp
Digital tools to enhance contextual or multimedia information of pieces of art	**Quick Response code - QR codes** connect collections with data that can deepen their meaning; improve emotional engagement by enhancing the exploration experience with museum specimens; foster the learning process by making information easily accessible and linkable.	Archaeological Museum "Giuseppe Moretti".	Italy	115 13- to 16-year-old students, 10 students of the Academy of Fine Arts and a group of 20 adults.	EMMAP format.	Yes	Small group where everyone has a leader/explorer/reporter role; by collaborating participants solve quizzes (gamification) and then move on to the next museum room (that is a new quiz).	https://www.sciencedirect.com/science/article/pii/S0747563212001586

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Quick Response code - QR codes connect collections with data that can deepen their meaning; improve emotional engagement by enhancing the exploration experience with museum specimens; foster the learning process by making information easily accessible and linkable.	Nottingham Lakeside Arts gallery.	UK	28 adults.	ARTcodes (publicly available).	Yes	Free exploration of the exhibit; creation of hybrid artefact comprising a visual code and audio recording.	https://www.researchgate.net/publication/325704696_Deepening_Visitor_Engagement_with_Museum_Exhibits_through_Hand-crafted_Visual_Markers
	Augmented Reality - AR augments your surroundings by adding digital elements to a live view, often by using the camera on a smartphone. It enhances the discovery-based learning process and promote emotional engagement. It is especially useful to overcome the inaccessibility and untouchability of objects.	N/A	UK	19 children.	Development of an AR app (not specified)	Yes	Free exploration of the museum (30 minutes) to find out points of interest through the AR app	https://www.tandfonline.com/doi/abs/10.1080/09647775.2019.1578991?journalCode=rmmc20
	Augmented Reality - AR augments your surroundings by adding digital elements to a live view, often by using the camera on a smartphone. It enhances the discovery-based learning process and promote emotional engagement. It is especially useful to overcome the inaccessibility and untouchability of objects.	Bayonne's Museum of Art and History.	France	17 adults.	M.A.R.T.S.	Yes	Participants used labels, audio-guide and M.A.R.T.S separately in a random order and in a way thatensures that each exhibit is explored only once during the experimentation.	https://www.researchgate.net/publication/317301714_Mobile_Augmented_Reality_in_Museums_Towards_Enhancing_Visitor's_Learning_Experience

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	The **app** Sketchfab was set up to use in computers and mobile telephones. **3D images** of 10 sculptures from the museum collection. **Descriptive texts** accompany the images which are also available in **audio**.	Sculpture museum Einar Jónsson.	Iceland	Children 8-14.	Open	Autonomously		https://brokkoli.is/wp-content/uploads/2022/02/LEJ_Stafraenar-styttur_verkefni_yfirlesid.pdf
	From the Barracco Museum website: **Li-Fi**, which stands for **Light Fidelit**y, exploits the use of **LED light to transmit data to smartphones or tablets**. The Li-Fi light device plays the role of transmitter, while the mobile device, equipped with a camera, is the receiver. This creates a very high-speed data network with important feature: directionality, because the devices communicate only when illuminated by the light emitted by the light fixture, ensuring a high level of security. The use of this technology in the Barracco Museum has seen the definition and implementation of a short but significant route, consisting of a number of points of interest on the ground and second floors of the Museum, suitably illuminated by Li-Fi spotlights. Thanks to Li-Fi, it is possible to create a flexible and reconfigurable internal geolocation system, which allows visitors to visit the Museum with the support of multimedia content (photos, videos, infographics, etc.) that greatly enriches the visitor experience.	From the Barracco museum website: Museum of Ancient Sculpture Giovanni Barracco. The collection of the Museum, set up in a suggestive sixteenth-century building, consists of about 400 works that testify the Egyptian, Mesopotamian, Phoenician, Cypriot, Greek, Etruscan and Roman figurative cultures,, also offering examples of medieval art. All in one exhibition divided into 9 rooms on three floors. Similar project: Smart@Pompei.	Italy	All visitors, blind, visually impaired.	To Be Srl, DB Ingegneria dell'immagine Srl, Tecno Electric Srl	Partially autonomously. To use the multimedia contents, users have to download the appropriate App (roll up and QR code are availble at the entrance of the museum) and place the own smartphone or tablet under the light of the Li-Fi spotlight.	Not available yet	http://www.museobarracco.it/; https://tobe-srl.it/

Erasmus+
Project n. 2021-1-IT02-KA220-HED-000031991

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	From the Ara Pacis museum website: Audiopen: audio-description, on Audiopen, which guides the blind and visually impaired visitor in the exploration of the drawings in relief and in the knowledge of Doisneau's work. The Audiopen is activated simply by pointing the pen on a code placed on the relief drawing; to listen to the audio story, visitors can use their own earphones or headphones made available by the museum. The Audiopen is free and is issued at the ticket office upon presentation of an identity document. From the Ara Pacis Museum and exhibition **website there is a section dedicated to accessibility** where you can: 1) download the **maps for blind and visually impaired visitors;** 2) obtain all the information about the routes; 3) download the a**udio tracks and pdf texts and insights**; 4) download room texts and chronology; 5) download the calendar of tactile tours; 6) download the calendar of guided tours with LIS interpreter; 7) download the **LIS video of the exhibition**. The device is used in other museums such as the Reggia di Venaria in Turin, the Scrovegni Chapel in Padua, and Notre Dame in Paris.	Summary from the Ara Pacis Museum website: "Robert Doisneau" exhibition (Ara Pacis Museum Augustae 28.05-04.09.2022). The Capitoline Superintendence, in order to increase the inclusiveness of museum spaces and support participation in cultural life, has made available various tools and dedicated tours to promote awareness of the French photographer's work.	Italy	All visitors, blind, visually impaired.	Sycomore	Not autonomously. From the Ara Pacis museum website: To support the visit experience by the blind and visually impaired people, the Ara Pacis Augustae Museum, in collaboration with the Omero State Tactile Museum of Ancona and with Zètema, made available to visitors: six relief drawings positioned along the exhibition path, in correspondence with the original photographs; an audio description, on Audiopen activated by pointing the pen on a code placed on the relief drawing; to listen to the audio story, visitor can use their own earphones or headphones made available by the museum.	Not available yet	https://www.arapacis.it/it/infopage/robert-doisneau-accessibilit-mostra; https://www.arapacis.it/sites/default/files/f_immagine/Ara%20Pacis_Robert%20Doisneau_traccia%20audio%2005.mp3
Digital tools to contextualize simulations of real pieces of art	**Virtual Reality - VR** is a completely immersive experience that replaces a real-life environment with a simulated one. It enables a deeper and more meaningful understanding of museum objects.	Hönnunarsafn Islands Museum of Design and Applied Art.	UK, Iceland	34 adults; 12 college students; 24 middle school pupils.	Prototype (not specified).	Yes	Visit of a VR exhibit through a VR app prototype	https://web.wpi.edu/Pubs/E-project/Available/E-project-100819-143110/unrestricted/Archiving_a_Museum_with_an_Interactive_Exhibit.pdf

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Virtual Reality - VR is a completely immersive experience that replaces a real-life environment with a simulated one. It enables a deeper and more meaningful understanding of museum objects.	British Museum, Yorkshire Museum.	UK	253 respondents.	Viking VR	Yes	Far from a solitary experience, visitors used the headsets to discuss what they were seeing with their friends and families, drawing attention to specific features and making connections between the activities in each vignette.	https://eprints.whiterose.ac.uk/129158/1/vikingvr_preprint.pdf
	3D printing - The Prado Museum in Madrid is displaying six 3D replicas of famous paintings, which visually impaired visitors can explore through touch. The exhibition is called Touching the Prado and was created by Spanish printing studio Estudios Durero using a printing technique they invented called Didú. The replicas are produced through a painstaking forty hour process which sees the printers selecting textures and volumes, including tiny details which will help to guide the blind person's hand around the painting, helping them to understand the composition. The textures are printed first and a chemical method gives the image volume. After this, the original image is printed on top.	Museu del Prado (Prado Museum)	Spain	Blind and visually impaired visitors.	Not available	No	Not available	https://www.springwise.com/madrid-gallery-blind-visitors-touch-masterpieces/

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	3D printing + Interactive exibitors + Mobile APP with Augmented Reality Through PhD scholarship at FEUP (Faculty of Engineering of the University of Oporto) Roberto Vaz saw the opportunity to make a difference with practical applications within museum institutions. The exhibition "Mysteries of the Art of Healing: A multisensory experience through 5000 years of history", a partnership between FEUP and the Museu da Farmácia do Porto, is an example with all the conceptualization, production and assembly of the exhibition being the responsibility of the researcher. In addition to the broadly inclusive experience, for which Roberto Vaz also contributed to the 3D printing of objects from the museum's collection and the prototyping of interactive exhibitors, a mobile application that uses the augmented reality technique is being developed in partnership with a colleague Maria Van Zeller, and also involves the visually impaired public.	Museu da Farmácia do Porto (Pharmaceutical Museum of Oporto).	Portugal	Visually impaired visitors.	Not available	No	Not available	https://www.sciencedirect.com/science/article/pii/S1877050918317228; https://www.museudafarmacia.pt/detalhe.aspx?lang=PT&uid=0&area=exposicoes&o=2&f=30&bid=77

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology – short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Museum traveling project 'Today it's time for the Prado' in which **six tactile reproduction**s are exhibited corresponding to different genres and artistic styles that reflect the richness of its collections.	Museo de Lleida, Museo de Zaragoza, Museo del Prado.	Spain	People with visual disability.	Exclusive use	Autonomously		https://www.once.es/noticias/el-museo-de-lleida-inaugura-2018hoy-toca-el-prado2019-con-reproducciones-en-relieve-de-obras-que-las-personas-ciegas-podran-disfrutar-con-las-manos
	Touch mockup of Torre de María de la Sacred Family Basilica	Sagrada Familia Basilica and Espacio Gaudí (Barcelona).	Spain	Blind people.	Exclusive use	Autonomously		https://www.servimedia.es/noticias/personas-ciegas-podran-ver-dedos-torre-maria-sagrada-familia/3424977
	A **platform with a 3D system** allows people with mobilityreduced visit the Punic Wall of Cartagena	Interpretation Center of the Punic Wall of Cartagena and the Univeridad Politécnica de Cartagena.	Spain	Motor disabled users.	Exclusive use	Autonomously		https://www.murcia.com/cartagena/noticias/2022/03/21-una-plataforma-con-sistema-3d-permite-a-las-personas-con-movilidad-reducida-visitar-la-muralla-punic.asp
	The **app** Sketchfab was set up to use in computers and mobile telephones. **3D images** of 10 sculptures from the museum collection. **Descriptive texts** accompany the images which are also available in **audio**.	Sculpture museum Einar Jónsson.	Iceland	Children 8-14.	Open	Autonomously		https://brokkoli.is/wp-content/uploads/2022/02/LEJ_Stafraenar-styttur_verkefni_yfirlesid.pdf
	Original art works and copies (1:1 scale), explorable and modular architectural models, bas-relief and tactile tables. Audiopen pen also accompanies and guides the visitor along the exhibition paths. The entire collection is accessible and usable in a tactile way: to support people with visual disabilities there are descriptions in Braille, in black and in large characters, mobile platforms for the exploration of the highest parts of the sculptures.	State Tactile Museo Omero.	Italy	All visitors, blind, visually impaired.	Museum	Autonomously	N/A	https://www.museoomero.it/

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	For the **temporary exhibition** "LUCIO DALLA. Anche se il tempo passa" Ara Pacis Museum, specific actions and tools planned to promote awareness of the Bolognese singer-songwriter To enable the blind and visually impaired public to enjoy the works on display in the exhibition, the Ara Pacis Augustae Museum, in collaboration with the Museo Tattile Statale Omero and Zètema Progetto Cultura, provides: 1)the **relief map of the exhibition**; 2)six **tactile panels in Braille with easy-to-read texts**, positioned along the exhibition route; 3)six **audiodescriptions on Audiopen**, which accompany visitors in their enjoyment of the exhibition (the Audiopen is free and available upon request at the ticket office and is activated by simply pointing it at the raised code located on the relevant panel; 4) advance downloads of all maps, texts and audio content; 5) **tactile tours** conducted by a trained operator; 6) enjoyment of some audio content intended for hearing and deaf visitors; 7) some **videos of performances**, made in collaboration with the Social Cooperative Segni di Integrazione - Lazio, made in the universal language of the body to visually convey the words of the texts, melodies and rhythms; 8) a calendar of **guided tours with L.I.S. interpreter**, organized in collaboration with the Department of Social Policy and Health, Department of Personal Services, the non-profit social cooperative Segni di Integrazione - Lazio and Zètema.	From Ara Pacis Museum website, "the Capitoline Superintendence continues its efforts to extend accessibility services to temporary exhibitions as well." Temporary exhibition - LUCIO DALLA. Even if time passes 22/09/2022 - 06/01/2023 Ara Pacis Museum, Exhibition Space. Exhibition-event dedicated to one of the most beloved Italian and international artists on the tenth anniversary of his death, to celebrate his human and musical genius. A visual and sensory journey, an immersive experience that transforms the exhibition space into a scenic box.	Italy	All visitors, blind, visually impaired, deaf people.	Sycomore for the audiopen	Autonomously, for the audiopen partially autonomously.	Not available yet	https://www.arapacis.it/en/node/1011491

Erasmus+
Project n. 2021-1-IT02-KA220-HED-000031991

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
Digital methodologies to enhance learning processes	**Digital Storytelling** - DST attracts and satisfies the audiences of museums and other cultural heritage sites, and supports teaching and learning at every level of education.	Acropolis Musuem.	Greece	28 visitors; museum staff.	CHESS Authoring Tool.	Yes	N/A	https://www.researchgate.net/publication/290082841_CHESS_Personalized_Storytelling_Experiences_in_Museums
	Digital Storytelling - DST attracts and satisfies the audiences of museums and other cultural heritage sites, and supports teaching and learning at every level of education.	Acropolis Museum; University of Athens museums; Hunterian Museum; Çatalhöyük Neolithic Site; University of Athens History Museum; Criminology Museum of Athens.	Greece; UK; Turkey	60 participants in total (archaeologists, museologists, cultural heritage experts, creative designers).	Narrative Storyboard Editor.	Yes	Participants, given minimal guidelines as to the type of experience to design, pushed the boundaries of the tool with alternative uses of activity templates and unforeseen story structure approaches, resulting in a variety of experience types.	https://www.researchgate.net/publication/337729466_Narralive_--_Creating_and_experiencing_mobile_digital_storytelling_in_cultural_heritage
	Hands on - Hands on approaches are based on constructivism and the role of physical actions for learning. They especially promote emotional engagement and critical thinking.	Tinkering Lab, permanent exhibit at Chicago Children's Museum.	USA	61 families with 6- to 8-year-old children.	physical objects, materials, working tools	Yes	On average, families spent 38 minutes tinkering (range = 9–143). Joint hands-on engagement during tinkering was not associated with engineering design process talk when reminiscing.	https://www.sciencedirect.com/science/article/pii/S0022096520303982

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology – short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Hands on – Hands on approaches are based on constructivism and the role of physical actions for learning. They especially promote emotional engagement and critical thinking.	Study 1: Ann Arbor Hands-On Museum; study 2:Children's Discovery Museum of Elgin.	USA	Study 1: 120 children; study 2: 40 children.	tangram exhibits.	Yes	Preference for partially completed exhibits over uncompleted exhibits.	https://www.sciencedirect.com/science/article/pii/S0361476X96900119
	Original art works and copies (1:1 scale), explorable and modular architectural models, bas-relief and tactile tables. Audiopen pen also accompanies and guides the visitor along the exhibition paths. The entire collection is accessible and usable in a tactile way: to support people with visual disabilities there are descriptions in Braille, in black and in large characters, mobile platforms for the exploration of the highest parts of the sculptures.	State Tactile Museo Omero.	Italy	All visitors, blind, visually impaired.	Museum	Autonomously	N/A	https://www.museoomero.it/

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	For the **temporary exhibition** "LUCIO DALLA. Anche se il tempo passa" Ara Pacis Museum, specific actions and tools planned to promote awareness of the Bolognese singer-songwriter To enable the blind and visually impaired public to enjoy the works on display in the exhibition, the Ara Pacis Augustae Museum, in collaboration with the Museo Tattile Statale Omero and Zètema Progetto Cultura, provides: 1)the **relief map of the exhibition**; 2)six **tactile panels in Braille with easy-to-read texts**, positioned along the exhibition route; 3)six **audiodescriptions on Audiopen**, which accompany visitors in their enjoyment of the exhibition (the Audiopen is free and available upon request at the ticket office and is activated by simply pointing it at the raised code located on the relevant panel; 4) advance downloads of all maps, texts and audio content; 5) **tactile tours** conducted by a trained operator; 6) enjoyment of some audio content intended for hearing and deaf visitors; 7) some **videos of performances**, made in collaboration with the Social Cooperative Segni di Integrazione - Lazio, made in the universal language of the body to visually convey the words of the texts, melodies and rhythms; 8) a calendar of **guided tours with L.I.S. interpreter**, organized in collaboration with the Department of Social Policy and Health, Department of Personal Services, the non-profit social cooperative Segni di Integrazione - Lazio and Zètema.	From Ara Pacis Museum website, "the Capitoline Superintendence continues its efforts to extend accessibility services to temporary exhibitions as well." Temporary exhibition - LUCIO DALLA. Even if time passes 22/09/2022 - 06/01/2023 Ara Pacis Museum, Exhibition Space. Exhibition-event dedicated to one of the most beloved Italian and international artists on the tenth anniversary of his death, to celebrate his human and musical genius. A visual and sensory journey, an immersive experience that transforms the exhibition space into a scenic box.	Italy	All visitors, blind, visually impaired, deaf people.	Sycomore for the audiopen	Autonomously, for the audiopen partially autonomously.	Not available yet	https://www.arapacis.it/en/node/1011491

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology - short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
	Gamification - Gamification refers to the use of game elements and game-design techniques in non-game contexts. Gamification is widely used in museum contexts for its ability to influence the decision of visitors to attend museums; improve the learning experience; control and direct crowds.	PP-IPTEK Museum TMII, Indonesia.	Indonesia	Museum visitors.	"Museum Adventure" game app created by the research group	Yes	Visitors tested the app.	https://www.jesrjournal.com/uploads/2/6/8/1/26810285/011-_jesr-71-76-volume_2_issue_1_2018.pdf
Sensory-based technologies	**Multisensory tools (braille texts, scent interpretations, tactile drwings and soundscapes, mobile apps)** BLIND AND PARTIALLY SIGHTED - On this guided multi-sensory tour for blind and partially sighted visitors. DEAF AND HARD OF HEARING VISITORS - The exhibition Delinking and Relinking, on display from September 2021 to the end of 2024, is the first fully multi-sensory collection display in the Netherlands. With **over 25 multi-sensory tools, including texts in Braille, scent interpretations, tactile drawings and soundscape**s, Delinking and Relinking makes artworks accessible to a wide audience, including visually or hearing-impaired visitors and wheelchair users. The Van Abbemuseum offers several free and digital tours via the Smartify app, including two in Sign Language of the Netherlands (SLN). You can choose language settings via the dropdown menu at the top.	Van Abbemuseum for contemporary arts in Eindhoven.	Netherlands	Blind and partially sighted visitors; hard of hearing visitors	Not available	Yes	Not available	https://vanabbemuseum.nl/en/mediation/inclusion/

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2 Handbook on the use of technology for inclusive educational activities in museum context

Mapping the technologies

Technology clusters	Type of technology – short description	Museum context in which it is applied/cases	Country/ies	Target groups	Exclusive patent or open	Usable autonomously or not	Usage data	Links
Technologies for studying visitors' emotions and preferences	**Selfies at the museum** – it is used to better understand visitors' behavior, establish a closer connection to the exhibited objects, provoke emotions, co-create value and promote the museum content.	National Gallery of Victoria.	Australia	Museum visitors (observation on the field and 10 semi-structured interview).	Open	Yes	Visitors were encouraged to take selfies and this action was analyzed through in field observations, netnography method and semi-structured interviews.	https://www.researchgate.net/publication/344212482_artoninstagram_Engaging_with_Art_in_the_Era_of_the_Selfie
	The **APP Recuperart-19** aims to transform an art-based activity notebook into the digital and interactive application for mobile phones. In this APP the user will find the different steps to complete the experience of Recuperart-19, a therapeutic path through selected pieces of art in a museum context. The goal is the use of museums as significant environments for self-reflection and improvement of emotional well-being. Recuperart-19 involves 15 different museums in Catalunia. Using the APP instead of the paper-based activity will 1) A potential increase of the participant museums 2) Increase general participants 3) Possibility to simultaneously target specific groups of participants 4) Monitor the activity 5) Improvement of the evaluation of the health and wellbeing outcomes 6) Increase of the functionalities and activities of the intervention 7) Increase of the inclusion of the activity . Activities, have been validated and designed by a group of medical professionals) and are focused on exercises based on a mix of mindfulness techniques, concentration, focus, cognitive association, creativity, writing, drawing, and reflection. Thanks to the APP interactivity activities can improve the experience by exploring other dimensions such as the sound. The software ensures that the user can have and feel the connection with the museum. It is essential for the activity that participants be connected to the surroundings of the museum and not to be so evaded of the space. The APP incorporates different evaluation tools. 1) to assess the perceived effect of the activity on the participant's mental well-being 2) The evolution of the participant's mental well-being after the activity (mood tracker).	It is designed for the intervention Recuperart-19, that was born in the pandemic context to improve the mental health and well-being of the Institut Catala de la Salut's health professionals.	Catalonia (Spain)	Health professionals, students, school groups.	Exclusive patent	Users can use it autonomously and as many times as they wish.	The app collects personal data such as the name, surnames and email of the user. Also, because of its nature, it compiles data about the mood of the user.	

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

PR2.A3 - "Short report on evaluation and assessment of museum-based activities for health and well-being development through technology"

Results 2 | Activity three	
Title: Short report on evaluation and assessment of museum-based activities for health and well-being development through technology	
Delivery	September 2022
Leader /Co-Leader	Università degli Studi di Modena e Reggio Emilia
Review	October 2022

The creation of these resources has been funded by the ERASMUS+ grant program of the European Union under grant no. 2021-1-IT02-KA220-HED-000031991. Neither the European Commission nor the project's national funding agency are responsible for the content or liable for any losses or damage resulting from the use of these resources.

Print

This publication is number PR2.A3 of the strategic collaboration founded by the ERASMUS+ grant program of the European Union under grant no. 2021-1-IT02-KA220-HED-000031991 | **(https://piattaformaintellect.it/portale/index.php/outputs/)**

PDF download

A full PDF version of the text is available and can be downloaded free of charge from the website:

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Introduction

The short report presented here is realised by UNIMORE and aims to identify which ICT can be used in museum contexts to evaluate well-being and how they measure it.
The need to include assessment in the list of museum educational activities is undoubted. Assessment allows feedback, which helps the understanding of museum experiences' impact on museum visitors: changes in behaviour, emotional perception, and adaptive measures might be taken into consideration and adopted in the future to design and carry out similar and more effective experiences.
The short report contributes to developing specific and updated research on the topic by analysing the ICT evaluation of museum experiences that promote well-being and defining the most relevant information on individual well-being that assessment technologies and tools can provide.
In this regard, it is worth noting that the definition of well-being here adopted is threefold and based on the research carried out in PR2.A1. Therefore, the concept of well-being is articulated in three main areas:

1. health sphere, i.e. in terms of psycho-physical well-being;
2. pedagogical field, i.e. in terms of competencies for active citizenship;
3. psychological field, i.e. in terms of emotional engagement.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Methodology

This report builds upon a previous inquiry phase. Firstly, clusters of technologies able to foster well-being were identified. Secondly, based on these clusters, relevant scientific papers were selected according to common criteria previously established. Peer-reviewed and open-access papers were selected, which have been published no longer than the last 20 years. Searches were conducted on Google Scholar, Academia, Research Gate, ERIC, SCOPUS, and other sectoral databases. The keywords adopted throughout the search activity were the following: the name of the technology; museum; inclusion; health; wellbeing; inclusion; interventions; strategies; practices; experiences; competencies; learning; emotions; education.
Thirdly, a content analysis was conducted on the selected papers by taking into account the following: the technology itself; its current field(s) of application; case studies; the main focus of the experience; costs. This step of the research was fundamental to identify best practices that promote well-being and social inclusion through technologies and with particular reference to the use of museum objects, transversal skills development and acquired knowledge.

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

Findings

The selected papers illustrate case studies from Europe, the anglo-saxon and east-asian area. ICTs are increasingly adopted in museum contexts to improve the general experience of visitors, boost their emotional engagement, transfer new knowledge, and develop transversal skills that are essential for active citizenship. These objectives are aligned with the threefold definition of well-being adopted for this project. However, there is an evident gap in the literature concerning the employment of ICT in museums for assessment purposes, which could also be related to the widespread difficulty of museums in including evaluation systematically within their educational programmes. Based on the objectives pursued and the results highlighted in the case studies examined, most of the below-mentioned technologies have the potential to be used for evaluation purposes.

1. ICTs for well-being evaluation in museum contexts

Data collection is fundamental for an evidence-based well-being evaluation. In the museum fields, well-being evaluation and assessment could rely on a vast array of methods. Not only through visitors self-reports, that usually depend on retrospective recollection, but also through new technologies adopted in the museums contexts, as well as personal mobile technology, such as smartphones and wearable sensors, that have the potential to capture an accurate picture of visitors' reactions when engaging in cultural activities. Momentary assessment through technology gives the opportunity to look at how visitors' reactions vary over time, and could give insights into how these reactions vary in different contexts.
According to the classification proposed by Areán *et al.* (2022), four different types of data can be usefully collected through ICT to assess the level of personal wellbeing:

- self report, that requires responses from the visitor;
- performance data, collected during a visitor performance when engaging in an activity;
- sensor data, that can be collected from sensors from various devices or wearable sensors;
- social media data collected by personal devices and Internet activity.

Self-report. These tools are the simplest methods of technology-based data collection and consist of the delivery of standardised questionnaires over platforms or devices adopted in the museums, whose softwares can be customised to implement them.
Performance data. When a visitor is engaging in a specific activity or task over an app or a device, data on how they perform on that task can be collected. In mental health, the most common performance-based assessment apps are those that deliver competencies and skills assessments over game-like platforms. In general, it is possible to measure attention, concentration, and working memory. As the visitors use the app/device, data is collected on the number of errors, reaction time, and other task-based measures of performance.
Sensor data. sensors have the potential to collect a warehouse full of physiological, social, emotional, and behavioural data: sensors embedded in smartphones or other mobile or fixed devices can measure important functional behaviours, such as physical activity and physical location. Wearable sensors can also detect physiological data, such as blood pressure, galvanic skin response, heart rate, and respiration.

Social media data. Social data collected from smartphones and other devices include a combination of incoming and outgoing text frequency, length of texts, and number of people contacted, as well as the content of public messages sent via social media (eg, Twitter). This data can serve as a proxy for social connectivity.
Considering the aforementioned type of data collection through ICT, the following table summarises which technology allows the specific assessment activity.

Types of data	**Technology**
SENSOR DATA	Virtual tours (if it involves Head Mounted Display)
	Radio beacons
	Indoor GPS tracking systems
	NFC TAGS
	A.I. for identifying visitors' behaviours and preferences
	Software Mezzini
	Eye-tracking for mapping emotional responses during museum visits
	Smartwatch for mapping emotional responses during museum visits
SELF REPORT	Videoguides
	Information Totems
	Augmented Reality
	Virtual Reality
	Virtual museums
	Physical visits systems -Ipad on wheels
	Robots
	Wall projectors
	Gamification
	Heighten sensory awareness
	Video mapping show

	Selfies
	Gesture based technology
	Haptics
	Chatbots
	Virtual tours
PERFORMANCE DATA	Virtual tours (if the tour is gamified and participants need to conduct tasks)
	Audioguides
	Videoguides
	QR Code (NaviLens)
	Information Totems
	Augmented Reality
	Virtual Reality
	3D holographic projections (with gesture interface and chatbots)
	Physical visits systems -Ipad on wheels
	Wall projectors
	Heighten sensory awareness
	3D Printings models (in those activities that require visitor to engage with the design technology)
	Gamification
	Robots
	Gesture based technology
	Haptict
	Chatbots
	Video mapping show

	Digital Storytelling (if the visitors are asked to be editor of a story)
SOCIAL MEDIA DATA	Digital Storytelling (if visitors are asked to be editor of a story)
	Selfies

inclusive memory
INCLUSIVE MUSEUMS FOR WELL-BEING AND HEALTH THROUGH THE CREATION OF A NEW SHARED MEMORY

References

Altieri, A., Ceccacci, S., Giraldi, L., Leopardi, A., Mengoni, M., Talipu, A. (2021). Affective Guide for Museum: A System to Suggest Museum Paths Based on Visitors' Emotions. In M. Antona & C. Stephanidis. (Eds.), Universal Access in Human-Computer Interaction. Design Methods and User Experience. HCII 2021. Lecture Notes in Computer Science, 12768. Springer: Cham. https://www.researchgate.net/publication/352957675_Affective_Guide_for_Museum_A_System_to_Suggest_Museum_Paths_Based_on_Visitors'_Emotions

Areàn, P. A., Ly, K. H., Andersson, G. (2016). Mobile technology for mental health assessment. Dialogues in Clinical Neuroscience, 18 (2), pp. 163-169. https://www.tandfonline.com/doi/full/10.31887/DCNS.2016.18.2/parean

Argyriou, L., Economou, D. & Bouki, V. Design methodology for 360° immersive video applications: the case study of a cultural heritage virtual tour. Pers Ubiquit Comput 24, 843–859 (2020). https://doi.org/10.1007/s00779-020-01373-8

Atthasongkhro, J., Kanchanachaya, N., Nitjarunkul, N., Auksornnit, V., Tammachart, J. (2022). The Effect Of Using Virtual Reality Museum For Improving Learning Of The Users Of The Hall Of Southern Thai Culture, Princess Galyani Vadhana Institute Of Cultural Studies, Prince Of Songkla University. BiblioMed, 21(1), pp. 82-98. https://www.ilkogretim-online.org/fulltext/218-1644995975.pdf

Bagherzadhalimi, A., Di Maria, E. (2017). Design considerations for mobile robotic telepresence in museums- A report on the pilot users feedbacks. Advances in Robotics, Mechatronics and Circuits. https://silo.tips/download/design-considerations-for-mobile-robotic-telepresence-in-museums-a-report-on-the

Balzotti, C., Briani, M., Corbetta, A., Cristiani, E., Minozzi, M., Natalini, R., Suriano, S., Toschi, F. (2018). Forecasting Visitors' behaviour in Crowded Museums. Proceedings from the 9th International Conference on Pedestrian and Evacuation Dynamics (PED2018) Lund, Sweden – August 21-23. https://www.researchgate.net/publication/345093375_Forecasting_Visitors'_behaviour_in_Crowded_Museums

Bieszk-Stolorz, B., Dmytrów, K., Eglinskiene, J., Marx, S., Miluniec, A., Muszyńska, K., Niedoszytko, G., Podlesińska, W., Rostoványi, A. V., Swacha, J., Vilsholm, R. L., Vurzer, S. (2021). Impact of the availability of gamified e-guides on museum visit intention. Procedia Computer Science, 192, pp. 4358-4366. https://doi.org/10.1016/j.procs.2021.09.212

Boiano, S., Borda, A., Gaia, G. (2018). Chatbots and New Audience Opportunities for Museums and Heritage Organisations. Electronic Visualisation and the Arts (EVA), 9 - 13 July 2018. https://www.scienceopen.com/hosted-document?doi=10.14236/ewic/EVA2018.33

Boiano, S., Gaia, G. (2017) 5 Tips for Involving Teenagers in Your Museum Using a Chatbot. Invisible Studio, 27 June 2017. https://medium.com/@invisiblestudio/5-tips-for-involving-teenagers-in-your-museum-using-a-chatbot-bf88ff3ad568

Caggianese, G., De Pietro, G., Esposito, M., Gallo, L., Minutolo, A., Neroni, P. (2020). Discovering Leonardo with artificial intelligence and holograms: A user study. Pattern Recognition Letters, 131, , pp. 361-367. https://doi.org/10.1016/j.patrec.2020.01.006

Cesario, V., Coelho, A., Nisi, V. (2017). Audio Guides and Human Tour Guides: Measuring Children's Engagement & Learning at a Museum Setting. CHITALY 2017At: Cagliary, Italy, (1910). https://www.researchgate.net/publication/320558390_Audio_Guides_and_Human_Tour_Guides_Measuring_Children%27s_Engagement_Learning_at_a_Museum_Setting

De Miquel Santed, L., Baeza Albaladejo, R., & Fernández Azorín, T. (2022, January). Nuevo lenguaje, nuevas herramientas, nuevas experiencias: la visita virtual y las etiquetas Navilens en el Museo Arqueológico de Murcia. In CIMED21-I Congreso internacional de museos y estrategias digitales (pp. 421-435). Editorial Universitat Politècnica de València.

Design methodology for 360° immersive video applications: the case study of a cultural heritage virtual tour. Pers Ubiquit Comput 24, 843–859 (2020). https://doi.org/10.1007/s00779-020-01373-8)

Dima, M., Hurcombe, L., Wright, M. (2014). Touching the Past: Haptic Augmented Reality for Museum Artefacts. In R. Shumaker, S. Lackey (Eds.), Virtual, Augmented and Mixed Reality. Applications of Virtual and Augmented Reality. VAMR 2014. Lecture Notes in Computer Science, 8526. Springer, Cham. https://link.springer.com/content/pdf/10.1007/978-3-319-07464-1_1.pdf

Elbay, S. (2021). Distance education experiences of middle school 7th grade students in the Turkey during covid-19 pandemic: virtual museum example. Turkish Online Journal of Distance Education-TOJDE, 23(1). https://eric.ed.gov/?id=EJ1329801

Ferrato, A., Limongelli, C., Mezzini, M., & Sansonetti, G. (2022). Using Deep Learning for Collecting Data about Museum Visitor Behavior. Applied Sciences, 12(2), 533. MDPI AG. https://upcommons.upc.edu/bitstream/handle/2117/365733/Cepeda-Pacheco-Domingo2022_Article_DeepLearningAndInternetOfThing.pdf?sequence=1

Hai, H., Lo, W. H., Ng, H. H., Brailsford, T., & O'Malley, C. (2018). Enhancing reflective learning experiences in museums through interactive installations. 13th International Conference of the Learning Sciences (ICLS) 2018, pp. 776-783. https://uwe-repository.worktribe.com/output/867382/enhancing-reflective-learning-experiences-in-museums-through-interactive-installations

Hancock, M. (2016). Museums and 3D Printing: More Than a Workshop Novelty, Connecting to Collections and the Classroom. Bulletin of the Association for Information Science and Technology, 42(1), pp. 32-35. https://www.semanticscholar.org/paper/Museums-and-3D-Printing%3A-More-Than-a-Workshop-to-Hancock/f0d0577d10886964820dc443ffe1a65f6a79306chttp://doi.org/10.54941/ahfe1002174

Hutchinson,R., Eardley, A.F. (2021). Inclusive museum audioguides: 'guided looking' through audio description enhances memorability of artworks for sighted audiences. Museum Management and Curatorship. https://www.researchgate.net/publication/349754601_Inclusive_museum_audio_guides_'guided

_looking'_through_audio_description_enhances_memorability_of_artworks_for_sighted_audiences

Iio, T., Satake, S., Kanda, T. et al. (2020). Human-Like Guide Robot that Proactively Explains Exhibits. Int J of Soc Robotics 12, pp. 549–566. https://doi.org/10.1007/s12369-019-00587-y

Jadán-Guerrero, J., Mendoza, M., Acosta-Vargas, P., Nunes, I. (2022). Digital Learning Experiences in virtual Museums. In Isabel L. Nunes (Eds.), Human Factors and Systems Interaction. AHFE (2022) International Conference. AHFE Open Access, 52. AHFE International, USA.

Katifori, A. et al. (2014). CHESS: Personalized Storytelling Experiences in Museums. In A. Mitchell, C. Fernández-Vara, D. Thue. (Eds.), Interactive Storytelling. ICIDS 2014. Lecture Notes in Computer Science, 8832. Springer:Cham. https://www.researchgate.net/publication/290082841_CHESS_Personalized_Storytelling_Experiences_in_Museums

Krogh-Jespersen, S., Quinn, K.A., Krenzer, W.L.D., Nguyen, C., Greenslit, J., Price, C.A. (2020). Exploring the awe-some: Mobile eye-tracking insights into awe in a science museum. PLoS ONE 15(9). https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0239204&type=printable

L., Economou, D. & Bouki, V. Design methodology for 360° immersive video applications: the case study of a cultural heritage virtual tour. Pers Ubiquit Comput 24, 843–859 (2020). https://doi.org/10.1007/s00779-020-01373-8

Lee, C.I. (2022). Benefit Analysis of Gamified Augmented Reality Navigation System. Appl. Sci., 12, 2969. https://doi.org/10.3390/app12062969

Lee, H., Hyungsoo Jung, T., tom Dieck, M.C., Chung, N. (2020). Experiencing immersive virtual reality in museums. Information & Management, 57(5). https://doi.org/10.1016/j.im.2019.103229

Lowry, E., Jackson, N., Herchenroder L., Guy L. (2019). Archiving a museum with an interactive exhibit. A report to detail the process of creating an interactive, virtual reality exhibit for the Hönnunarsafn Íslands Museum of Design and Applied Art.October 8, 2019. https://web.wpi.edu/Pubs/E-project/Available/E-project-100819-143110/unrestricted/Museum_Final Presentation.pdf

Miyata, K., Takiguchi, T., Nakaguchi, T., Tsumura, N., Miyake, Y. (2008). An application of projection imaging systems for museum exhibitions. Proc. SPIE 6807, Color Imaging XIII: Processing, Hardcopy, and Applications, 68070L . https://doi.org/10.1117/12.765785

Moorhouse, N., Dieck, T., Jung, T. (2019) An experiential view to children learning in museums with Augmented Reality. Museum Management and Curatorship, 34(4), pp. 402-418. https://www.semanticscholar.org/paper/An-experiential-view-to-children-learning-in-with-Moorhouse-Dieck/5a4d9892b8826ff711e237e5826b40a724caa3fa

Nofal, E., Stevens, R., Coomans, T., Vande Moere, A. (2018). Communicating the Spatiotemporal Transformation of Architectural Heritage via an In-Situ Projection Mapping Installation. Digital Applications in Archaeology and Cultural Heritage.

Noh, Y. G., Hong, J. H. (2021). Designing Reenacted Chatbots to Enhance Museum Experience. Appl. Sci., 11, 7420.
https://www.researchgate.net/publication/353861001_Designing_Reenacted_Chatbots_to_Enhance_Museum_Experience

Okabe, A., Ohmura, R. (2016). Poster: Towards Creating User's Impression Map with Wearable Sensors. Proceedings of the 14th Annual International Conference on Mobile Systems, Applications, and Services Companion (MobiSys '16 Companion). Association for Computing Machinery, New York, NY, USA, 67. https://doi.org/10.1145/2938559.2948824

Piancatelli, C., Massi, M., & Vocino, A. (2021). #artoninstagram: Engaging with art in the era of the selfie. International Journal of Market Research, 63(2), pp. 134–160.
https://www.researchgate.net/publication/344212482_artoninstagram_Engaging_with_Art_in_the_Era_of_the_Selfie

Pujol, L., Roussou, M., Poulo, S., Balet, O., Vayanou, M. and Ioannidis, Y. (2012). Personalizing Interactive Digital Storytelling in Archaeological Museums: the CHESS Project. 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA), Southampton, UK, 26-29 March 2012, pp. 77-90.
https://www.madgik.di.uoa.gr/sites/default/files/2018-06/caa2012_paper_final.pdf

Rains, T., Barros, J. (2011). Wayfinding and visitor tracking in museums: accuracy assessments of hybrid positioning services. Conference: International Symposium on Spatio-Temporal Analysis and Data Mining.
https://www.researchgate.net/publication/291835739_Wayfinding_and_visitor_tracking_in_museums_accuracy_assessments_of_hybrid_positioning_services

Rhee, B. A., Pianzola, F., Choi, J., Hyung, W., Hwang, J. (2022). Visual content analysis of visitors' engagement with an instagrammable exhibition. Museum Management and Curatorship, pp- 1-15.
https://pure.rug.nl/ws/portalfiles/portal/200942332/09647775.2021.pdf

Rudametkin, W., Touseau, L., Perisanidi, M., Gomez, A., Donsez, D. NFCMuseum: an Open-Source Middleware for Augmenting Museum Exhibits. Opensource:
https://lig-membres.imag.fr/donsez/pub/publi/icps08-nfcmuseum.pdf

Schmidt, S., Steinicke, F. (2017). A Projection-Based Augmented Reality Setup for Blended Museum Experiences. ICAT-EGVE, pp. 1–2.
https://diglib.eg.org/bitstream/handle/10.2312/egve20171366/005-006.pdf

Schmidt, S., Steinicke, F., Irlitti, A., Thomas, B. H. (2018). Floor-Projected Guidance Cues for Collaborative Exploration of Spatial Augmented Reality Setups. Proceedings of the 2018 ACM International Conference on Interactive Surfaces and Spaces (ISS '18). Association for Computing Machinery, New York, NY, USA, 279–289.
https://basilic.informatik.uni-hamburg.de/Publications/2018/SITS18/floorUI.pdf

Schofield, G. P., Beale, G., Beale, N. E. (2018). Viking VR : Designing a Virtual Reality Experience for a Museum. DIS 2018 - Proceedings of the 2018 Designing Interactive Systems Conference. ACM DIS

Conference on Designing Interactive Systems, 09-13 Jun 2018 ACM, HKG, pp. 805-816. https://eprints.whiterose.ac.uk/129158/1/vikingvr_preprint.pdf

Shiomi, M., Kanda, T., Ishiguro, H., Hagita, N. (2007). Interactive Humanoid Robots for a Science Museum. IEEE Intelligent Systems, 22(2), pp. 25-32. https://ieeexplore.ieee.org/document/4136855

Stock O. et al (2007) Adaptive, intelligent presentation of information for the museum visitor in PEACH. User Modeling and User-Adapted Interaction, 17(3), 257-304. https://link.springer.com/article/10.1007/s11257-007-9029-6

Tokuoka, M., Mizoguchi, Egusa, R., Inagaki, S., Kusunoki, F. (2018). Effectiveness of a Cooperative Museum Learning Support System based on Multiple People Body Movements. International Journal of Education and Research, 6. https://www.ijern.com/journal/2018/November-2018/16.pdf

Trejo, K., Angulo, C., Satoh, S. Bono, M. (2018). Towards robots reasoning about group behaviourbehavior of museum visitors: Leader detection and group tracking. Journal of Ambient Intelligence and Smart Environments, 10(1), pp. 3-19, 2018. https://www.researchgate.net/publication/322609811_Towards_robots_reasoning_about_group_behavior_of_museum_visitors_Leader_detection_and_group_tracking

Vallez, N., Krauss, S., Espinosa-Aranda, J. L., Pagani, A., Seirafi, K., & Deniz, O. (2020). Automatic Museum Audio Guide. Sensors, 20(3), 779. https://doi.org/10.3390/s20030779

Vi, C. T., Ablart, D., Gatti, E., Velasco, C., Obrist, M. (2017). Not just seeing, but also feeling art: Mid-air haptic experiences integrated in a multisensory art exhibition. International Journal of Human-Computer Studies, 108, pp. 1-14. https://doi.org/10.1016/j.ijhcs.2017.06.004

Yoshimura, Y., Sobolevsky, S., Ratti, C., Girardin, F., Carrascal, J. P., Blat, J., & Sinatra, R. (2014). An Analysis of Visitors' Behavior in the Louvre Museum: A Study Using Bluetooth Data. Environment and Planning B: Planning and Design, 41(6), 1113–1131. https://arxiv.org/ftp/arxiv/papers/1605/1605.02227.pdf

Zancanaro, M., Kuflik, T., Boger, Z., Goren-Bar, D., Goldwasser, D. (2007). Analyzing Museum Visitors' Behavior Patterns. In Conati, C., McCoy, K., Paliouras, G. (Eds.), User Modeling 2007. UM 2007. Lecture Notes in Computer Science, 4511. Springer, Berlin, Heidelberg. https://www.researchgate.net/publication/221260782_Analyzing_Museum_Visitors'_Behavior_Patterns