Innovative, experiential and immersive technologies of place-based heritage outreach

Survey of international best-practices

Details

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1. Introduction

1.1 BLUE BALANCE project

The general objective of the BLUE BALANCE (VLAIO/ Blue Cluster) project is increasing public involvement and participation in the sustainable transition of the Flemish coastal area and, in so doing, the development of a societal 'license to operate' for sustainable (economic) activities. The project is aimed at residents of and visitors to the Flemish coastal area, and its objective is to initiate a more efficient dialogue between them and local corporate stakeholders and policymakers.

To achieve this goal, the project partners have adopted a multidisciplinary approach which encompasses social and environmental psychology, marine and maritime sciences, archaeology as well as media and communication sciences. The project focuses on the following specific targets:

- Conduct research into the personal values of people living in or visiting the Flemish coastal area to gain an in-depth insight into the underlying psychological motives, barriers and processes impacting individuals' support for and involvement in sustainable coastal innovations and processes as well as (their perception of) regional (group) norms and values.
- Link the long-term development of the coastal landscape and towns that boast cultural and natural heritage with sustainable innovations and topical issues. This in-depth map will be used to determine the optimum framing of messages (e.g. history, health, economy) and how this can be integrated into storytelling with a view to the sustainability agenda.
- Assess the stakeholder landscape and identify best practices, on the basis of previous and ongoing projects, to involve stakeholders in participatory processes, and determine for which future sustainability projects and innovations a societal 'licence to operate' is the most crucial.
- Investigate and test what interventions and communication tools can be used by stakeholders to make citizens aware, inform them and involve them.

The cSBO BLUE BALANCE project (July 2022 – December 2025) is coordinated by Marine@UGent, and project partners are the Center for Persuasive communication (CEPEC, UGent), the Historical Archaeology Research Group (HARG, UGent), the Flanders Marine Institute (VLIZ), the Department of Environmental Psychology (University of Groningen) and Digital Arts and Entertainment (DAE Howest).

1.2 Examining and developing intervention strategies for the Flemish Coast

The second work package (WP2) of BLUE BALANCE is aimed at the development of specific intervention strategies through a three-phased design. The first phase consists of a mapping of the coastal cultural heritage sites in Flanders (WP2a.1). Next the public awareness on the historical dimensions of landscape change, human resilience and sustainability on existing immersive experiences touching upon these topics is measured and interpreted

(WP2a.2). Finally, future sustainable interventions are conceptualized for development both within BLUE BALANCE (the so-called blueprints of WP3) and for further valorization trajectories (WP2a.3). The present deliverable D2a.4 buttresses this work package by evaluating international best practices on sustainable and educational touristic initiatives supported by the application of innovative, experiential and immersive technology, taking into account the sustainable aspects of tourism and heritage sites. At this point, no specific recommendations are included.

2. Methodology

This report's methodology is grounded in a literature review and screening of established, curated overviews. This dual approach serves two key purposes: first, to develop a theoretical framework around sustainable and educational immersive touristic initiatives in the heritage sector, and second, to identify effective practices in applying innovative, experiential, and immersive technologies. The initial literature review provided insights into state-of-the-art applications, though most literature focuses heavily on technological advancements rather than the broader impact on community engagement or sustainability. Virtual Reality (VR) applications emerged as a predominant area of focus within this body of work, offering detailed analyses on how VR enhances user experiences in tourism and heritage contexts.

Given the expertise of our technical partner, Digital Arts & Entertainment (DAE), this report places particular emphasis on VR and other 'high-tech' applications. However, we also examine 'low-tech' solutions due to their unique capacity to foster citizen engagement through more accessible, cost-effective technologies. Such approaches often encourage citizen science and can result in substantial community impact without the need for costly, high-tech implementations that run the risk of being affected by the digital divide These 'low-tech' practices demonstrate an alternative engagement model, potentially broadening the impact across diverse user groups.

In addition to heritage-focused applications, we analyzed initiatives specifically developed for tourism. Over the past decade, tourism-driven immersive technologies have flourished, largely due to their high economic value. With tourism playing an important role in our broader project objectives of the BLUE BALANCE framework, tourism-centered applications offer valuable insights and methodologies that can be adapted for heritage sites.

We have not included a strict timeframe or post-quem release date as a selection criterion. While we have made efforts to include some of the pioneers and early adopters where possible, the fast-paced nature of virtual reality technology means it quickly becomes outdated. Consequently, older applications often can no longer be regarded as 'best' practice. Furthermore, our research for this overview highlighted the challenges posed by 'digital decay' - the gradual loss or inaccessibility of older digital content due to factors like outdated technology, discontinued hosting, or changes in web standards - and 'link rot' where hyperlinks no longer lead to the intended destination because the content has been moved, deleted, or the website has gone offline. These factors make evaluating older practices even more challenging than assessing recent or current VR applications (as discussed in the next paragraph).

For recent and current VR application, the inability to fully assess their technological, content-based, and experiential effectiveness (i.e. 'impact') of applications without in-situ or VR testing, poses a significant challenge to thorough evaluation. Therefore, our analysis partially relies on curated overviews. This external 'proof of excellence' partially counterweights the inability to test and feel the application in the context they were developed for. Because we consider this desktop approach limits our ability to claim these examples as "best practices", instead, we classify them as "good practices." The curated overviews selected for this analysis include:

- European Capital Smart Tourism Competition
- European Heritage in Motion Awards
- European Heritage Awards - Europa Nostra
- European Time Machine Organisation (LTM Platform)
- European Prize for Citizen Science
- Heritage funding and support initiatives such as:
  - Heritage Keepers Ireland
  - National Lottery Heritage Fund UK
  - Mondriaan Fund – Netherlands

From these resources, we curated a selection of applications that exhibit innovative, immersive, and experiential qualities with an emphasis on sustainability and coastal heritage. Sustainability remains a priority in our selection criteria, though it introduces limitations in the range of applicable cases. Additionally, we focused on European projects because the majority of both scientific output on Cultural Heritage VR (80%) and most of the assets on the UNESCO World Heritage List are located in Europe (Rodriguez-Garcia et al., 2024). Because of the multi-sensorial character of the applications, we only selected applications from which proper imagery (photos and videos) was available. Finally, we also excluded all the applications that have been developed in Belgium and/or by the BLUE BALANCE partners, such those of the Zwin Lost Outports (HARG) or scan4stories (DAE).

For terminology and categorization, we mostly follow the taxonomy outlined by Rodriguez-Garcia et al. (2024) (see below 'some definitions'), ensuring a standardized approach to defining and analyzing innovative practices within the realm of sustainable tourism and heritage site management. This taxonomy enables consistent framing and comparison across diverse applications, contributing to a more structured understanding of the sustainable, educational, and immersive potential of these initiatives.

3. Theoretical background

3.1 Definitions

- eXtended Reality – XR: The umbrella that englobes all forms of immersion and interaction such as Augmented Reality (AR), Mixed Reality (MR) and Virtual Reality (VR)
- Augmented Reality – AR : A computer-generated system that enhances the real world by superimposing computer-generated information on top of it.
- Virtual Reality – VR : A computer-generated three-dimensional environment that one can navigate and possibly interact with, resulting in real-time stimulation of one or more of the user's five senses
- Mixed Reality – MR: An extended, more dynamic form of AR in an environment that allows for real-time interaction between real and virtual people and objects.
- Immersion : Immersion is a phenomenon experienced by an individual when being in a state of deep mental involvement in which their cognitive processes (with or without sensory stimulation) cause a shift in their attentional state such that one may experience disassociation from the awareness of the physical world.
- Presence : The sense of being in a virtual experience rather than in the place in which the participant's body is actually located.
- Low- or Non-immersive VR (NiVR): VR viewed on conventional screens or other 2D displays (computer screens or smartphones). It forms the basis of VR developments from the 1990s onwards.
- Semi-immersive (siVR): multi-user VR which is projected on large screens.
- Fully-immersive (fiVR) : uses head-mounted displays (HMDs) where users can be completely isolated from the real world by watching computer-generated views through the device.
- HMD: head-mounted displays.
- 3DoF: the user can interact with the environment by rotating the view, but the user cannot move around the virtual world. The 3 degrees correspond to the rotation of the 3 spatial axes (XYZ).
- 6DoF: not only can the user rotate the view, but the user can also move around the virtual world in all directions. This type of movement usually generates a greater sense of immersion. The 6 degrees correspond to the rotation and displacement of the 3 spatial axes.
- Passive VR: very limited user interactivity and movement, such as 360° environments.
- Explorative VR: free exploration of the virtual environment, although no direct interaction.

- Explorative interaction VR: the user can explore and interact freely with the virtual environment.
- Interactive experience VR: user interaction with the environment, but no free movement within it.
- LoS: Level of Size: largeness of the VR environment.
- LoD: Level of Detail (grain size) of the virtual reconstruction.
- LoH: Level of Hypotheses, the amount of (research) data that lies at the basis of the virtual reconstruction.
- Hologram: a three-dimensional image created by recording light patterns and reconstructing them in a way that allows the image to appear as if it is floating in space. When viewed, a hologram gives the illusion of depth and the ability to be viewed from different angles, simulating the appearance of a real, three-dimensional object.

3.2 Immersive Heritage

The concept of 'immersive heritage' has gained traction as an innovative approach within the cultural and heritage sectors. As defined by Kidd (2018), immersive heritage encompasses experiences that are story-led, centered on audience participation, multimodal, multisensory, and attuned to their specific environment. Rather than merely presenting historical or cultural content, immersive heritage positions itself as a bounded experience located at the intersection of narrative, bodily, and sensory perception.

Central to immersive heritage is its reliance on embodied interaction and the activation of multiple senses to create affective impact. This approach aims to simultaneously engage the senses—sight, sound, touch, and sometimes even smell or taste—thus heightening the emotional and personal resonance of the experience. By embedding physical participation and sensory stimulation within a narrative, immersive heritage fosters deep, personal connections with its audience, bridging historical or cultural content with present-day engagement.

The rise of immersive practices coincides with several broader developments in the cultural sector, often referred to as the "turns" identified by Kidd (2018). These include:

- The Narrative Turn: A shift toward diverse storytelling practices that seek to represent a broader array of voices and perspectives within heritage contexts. This movement aims to break away from monolithic or singular 'authoritative' historical narratives, embracing storytelling that resonates more deeply with varied audience backgrounds.

- The Affective Turn: A focus on exploring how museums and heritage sites influence visitors' emotions and the conditions under which these emotions inspire real-world actions. This is particularly relevant to initiatives like BLUE BALANCE, where the emotional impact of heritage experiences is intended to inspire deeper engagement with sustainability and conservation efforts.

- The Ludic Turn: The application of gamification, or play-based elements, in heritage experiences. Gamification enhances interaction, encouraging active participation through playful mechanisms that can help demystify complex content and engage younger or less traditional audiences.

A distinguishing feature of immersive heritage is its site-specificity. According to Farman (2014), narratives in immersive heritage are crafted to respond uniquely to the location they represent. This site-specific approach emphasizes qualities that are intrinsic to a particular place, shaping narratives that highlight characteristics that cannot be replicated elsewhere. By grounding stories within the unique physical or historical qualities of a site, immersive heritage fosters a powerful sense of place and contextual relevance that transcends generic or universal storytelling.

While immersive heritage frequently integrates both digital and physical resources, its essence is not defined by digital technology alone (Kidd 2018). Rather, its immersive quality emerges from the interplay of narrative, sensory engagement, and physical setting. Digital tools, when used, serve as vehicles to enhance the story and experience rather than as standalone defining features. This perspective underscores the adaptability of immersive heritage, showing that its effectiveness lies not in digital prowess but in the compelling, multisensory, and embodied experiences it creates.

3.3 Usefulness of VR in (Heritage) Tourism

Virtual Reality (VR) has become increasingly prominent in cultural heritage tourism, valued for its ability to reconstruct and provide access to lost or fragile heritage sites and material. As Rodriguez-Garcia et al. (2024) observe, VR, and especially the fully immersive variant (iVR), enables users to explore reconstructions of heritage sites that may no longer exist or are otherwise inaccessible. This capability to digitally revive lost heritage offers a unique pathway to connect audiences with history in a way that would be impossible through traditional means.

One of VR's most significant contributions to heritage tourism is its capacity to reach a broader audience while simultaneously addressing sustainability concerns. VR reduces the carbon footprint associated with travel and can help alleviate overcrowding at popular heritage sites, a pressing concern for heritage management (Itani & Hollebeek, 2021). Furthermore, VR mitigates accessibility limitations (Guttentag, 2010), a benefit that became especially critical during the COVID-19 pandemic when access to physical sites was restricted. By providing a digital alternative, VR contributes to site preservation and conservation efforts, minimizing physical wear on delicate structures and landscapes (Bec et al., 2021). Additionally, VR technology can digitally restore the original appearance of historical sites, thus preserving and showcasing heritage elements that might otherwise fade or be lost over time (Talwar et al., 2022; de Lurdes Calisto & Sarkar, 2024).

The potential of VR to inspire conservation behaviors has also been explored extensively. Hofman et al. (2022) highlight that VR, particularly through 360-degree immersive experiences, can be as impactful as real-life visits when it comes to influencing conservation actions (e.g. purchasing decisions, waste reduction or self-education).

Their study shows that VR elicits reactions similar to those experienced in physical environments, underscoring VR's potential as a tool to foster emotional connections and motivate environmental and heritage preservation behaviors.

VR's effectiveness as a tourism attraction lies not only in the reconstruction of sites but also in the quality of the virtual experience. Zhang et al. (2022) discuss how the design of virtual tourism projects and the appeal of digital destinations serve as critical pull factors for attracting visitors. The quality and authenticity of the VR experience are essential mediating factors that can enhance a site's perceived attractiveness and visitor satisfaction.

Finally, VR's role as a sustainable alternative has resonated strongly with consumers, particularly in the wake of the COVID-19 pandemic. Talwar et al. (2022) found that consumers now view VR as a viable and eco-friendly option for tourism and are willing to substitute physical travel with virtual experiences to help protect the environment. This willingness to embrace VR as a sustainable choice indicates a shift in consumer attitudes toward tourism and highlights VR's potential to reduce the environmental impacts associated with travel.

In summary, VR offers a range of benefits for heritage tourism, from providing access to inaccessible sites and reducing physical impact, to enhancing educational and conservation-related messaging. By addressing sustainability, accessibility, and engagement, VR technology is proving to be a valuable asset in the evolving landscape of heritage tourism.

3.4 Effectiveness of VR Experiences

The effectiveness of VR experiences within heritage and tourism is closely tied to the levels of absorption, presence, and immersion they provide. As noted by de Lurdes Calisto and Sarkar (2024), these three dimensions form the foundation of a meaningful VR experience. Absorption refers to the user's initial engagement with the experience at a certain psychological distance, acting as a precursor to immersion. Immersion occurs when users move beyond complete self-consciousness, experience altered perceptions of time, and become fully engaged in the virtual environment. Together, these elements enhance the user's feeling of "presence," the sensation of truly being within a recreated environment.

Achieving these immersive qualities relies on several key factors:

- Device Characteristics and Embodiment: The design and capability of VR hardware, including the extent to which users can feel physically represented (embodied) within the experience, play a crucial role. High degrees of embodiment enable a deeper connection to the virtual world and can significantly increase the sense of presence (Flavián et al., 2019).

- Interaction: The ability to interact with the virtual environment also contributes substantially to immersion. The more interactive the VR experience, the higher the potential for user engagement and the perception of presence. Higher degrees of freedom (DoF) in VR interaction, especially in educational contexts, have been associated with increased effectiveness (Rodriguez-Garcia et al., 2024).

- **Content Authenticity**: Nam et al. (2023) emphasize that the perception of authenticity—including factors like genuineness, accuracy, and realness—significantly affects users' sense of presence and satisfaction, particularly in heritage applications. Content that is factually realistic can create a stronger sense of presence, enhancing users' imagination and visual appeal, which, in turn, improves the overall quality of the experience (Orús et al., 2021).

- **Multisensory Stimulation**: Sensory elements like sound, smell, and tactile feedback can amplify the immersive quality of VR experiences by engaging users on multiple levels. The more senses that are stimulated, the more immersive and effective the experience becomes, enhancing presence and emotional impact (e.g. Flavián et al 2021).

In heritage VR experiences, atmospherics also play a vital role. VR users seek a sense of escape and authenticity; an effective VR experience can transport users to a different time, creating a setting that feels distinctly separate from their everyday lives. Nam et al. (2023) further argue that the atmospherics, alongside historical and cultural objects, are essential to achieving a perception of authenticity. This authenticity, driven by the right combination of visuals, activities, and sensory stimuli, helps evoke the feeling of stepping back in time, making the experience more impactful and memorable.

Best practices in VR for cultural heritage vary depending on the setting, as outlined by Rodriguez-Garcia et al. (2024):

- Museum Environments: In museums, VR experiences typically prioritize a high level of detail (LoD) and a high level of hypothesis (LoH) and a low level of size (LoS), often with three degrees of freedom (3DoF). This approach supports passive exploration while maintaining visual clarity and impact, which is particularly suited for group settings where individual interaction is minimized

- Educational Environments: In educational VR, a higher level size (LoS) and spatial freedom (6DoF) and exploratory interaction are emphasized, encouraging users to engage deeply with the content. While this setup may reduce visual detail in certain cases, it enhances (independent) learning and exploration, especially in XR (extended reality) applications where interaction is crucial (Bekele et al., 2021).

Heritage VR experiences are often passive and exploratory, allowing users to absorb historical information without high interactivity. However, this trade-off between freedom and immersion is context-dependent; in group-oriented museum experiences, limited user freedom can be beneficial, enabling greater visual impact without overwhelming the experience (Rodriguez-Garcia et al., 2024).

4. Good practices: Innovative, experiential and immersive technologies of place-based heritage outreach

In the following overview of good practices, we chose to group applications through the applied technology and/or conceptual approach. Because some of the projects feature multiple applications that could be mentioned under different technological categories (e.g. a VR-reconstruction with both a head-mounted display and a game-application), we only describe the most prominent feature of that project development.

The Panorama

Following the findings of Hofman et al (2022), in which particularly 360-degree immersive experiences in VR have the potential to inspire conservation behaviors, we first turn towards so-called 'panoramas' in this overview. The concept of using panoramas as immersive applications to showcase (local) heritage or land- and cityscapes dates back to the late 18th century, when Robert Barker made his first panorama of London. Much of the current 360°-immersive experiences are rooted in this late-18th and 19th-century proto-immersive concept. By including such an early example in the listed good practices, the historical background of immersive experiences becomes more evident. Because these immersive experiences are 'projected' on large screens and are often experienced in group, they qualify as so-called semi-immersive VR (SiVR).

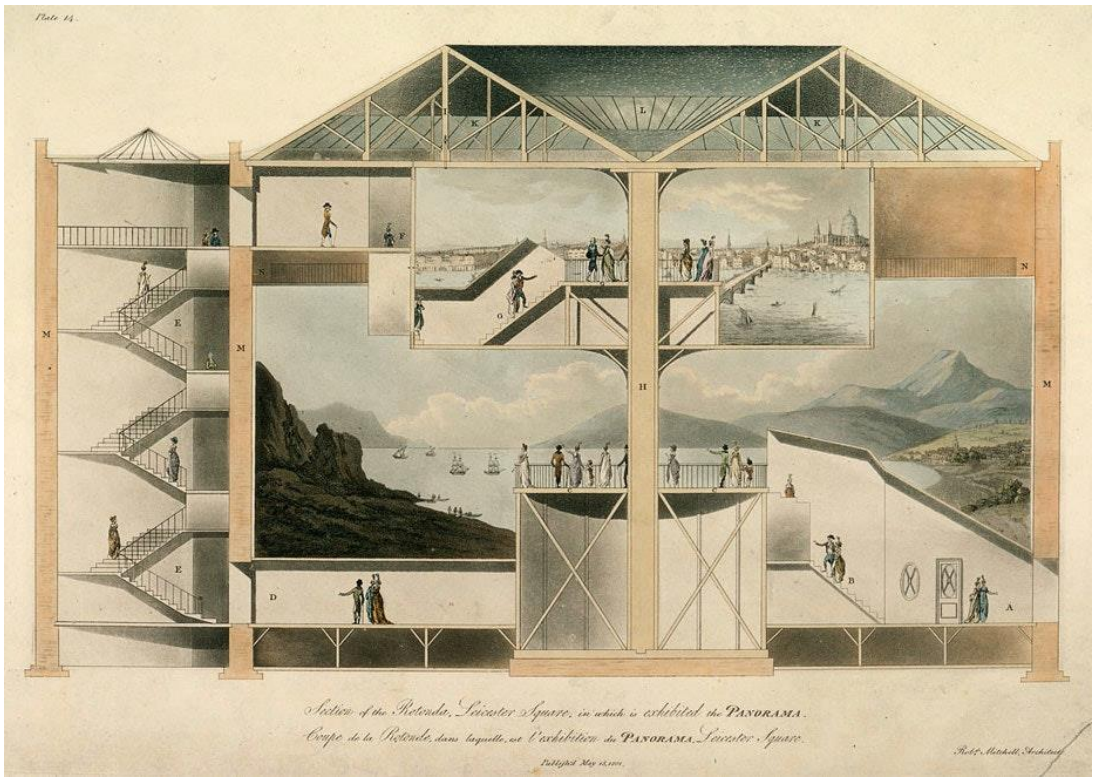


Figure 1: Cross-section of the Rotunda in Leicester Square in which the panorama of London was exhibited (1801) – Wikimedia.

Panorama Mesdag

The late-18th and 19th century witnessed the spectacular popularity of 360° painted panoramas, depicting local land- and cityscapes and often also battlefields. Large paintings, measuring +100m in length and +10m in height were placed in specially designed circular buildings, so-called 'rotundas'. Of the +300 panorama's that were painted in this timespan, only a few survived. The Panorama Mesdag in The Hague (The Netherlands) from 1881 , is one of those few remaining examples for which both the painting and the circular building are preserved.

Figure 1: The Mesdag Panorama – source: www.panorama-mesdag.nl

Especially relevant for BLUE BALANCE is that the Mesdag Panorama depicts the beach of Scheveningen and its immediate coastal surrounding. It was originally painted from the 'Seinpostduin' the highest vantage point in the dunes. Today, the panorama is elaborated as a standalone museum at its original location in The Hague. Visitors can view the panorama from a central circular construction. The space between this viewpoint and the painting is filled with original dune sand to gradually connect the visitor to the panorama and increase the authenticity of the experience. Audio tours are available to further guide and immerse visitors into the panorama. Additional to this original analogue immersive experience, the current museum in 2020 also made a high-resolution and zoomable digital image of the panorama which can be viewed on a 2D-screen. As an online visitor you can choose to freely explore the panorama yourself, audio-supported with a subtle sea-inspired sounds, and click on extra pop-up information (including on-demand audio recordings), as well as take a virtual tour in which a narrative voice automatically takes you through the panorama.

- Digital exploration of the panorama: https://panorama-mesdag.nl/en/#/micrio/explore

Panorama of Congo

One of the few Belgian panoramas that are preserved is the Panorama of Congo, commissioned by the colonial authorities of Belgium for the Colonial Pavilion at the 1913 International Exhibition (World Expo) in Ghent. Since its last display in Brussels in 1935, it has never been shown again. In the ongoing project 'Decolonizing the Panorama of Congo', the panorama is being imaged and recontextualized in VR. More than simply digitize and preserve, the project Portuguese and Belgian partners aim to contextualize this panorama into the ongoing debates on the decolonization of museum collections and to prepare this heritage for future generations and critical engagement by different stakeholders, seeking multi-faceted and polyphone narratives of Europe's colonial past. In specific VR-workshops with head-mounted displays (HMD), like on 'Wetenschapsfestival Gent', the VR-visitors are asked to contribute with their own interpretations of the historical panorama, in the spirit of citizen science and user-response data collection. This interactive set-up aimed at engagement, critical thinking and attitude change, makes it very relevant for the BLUE BALANCE project.

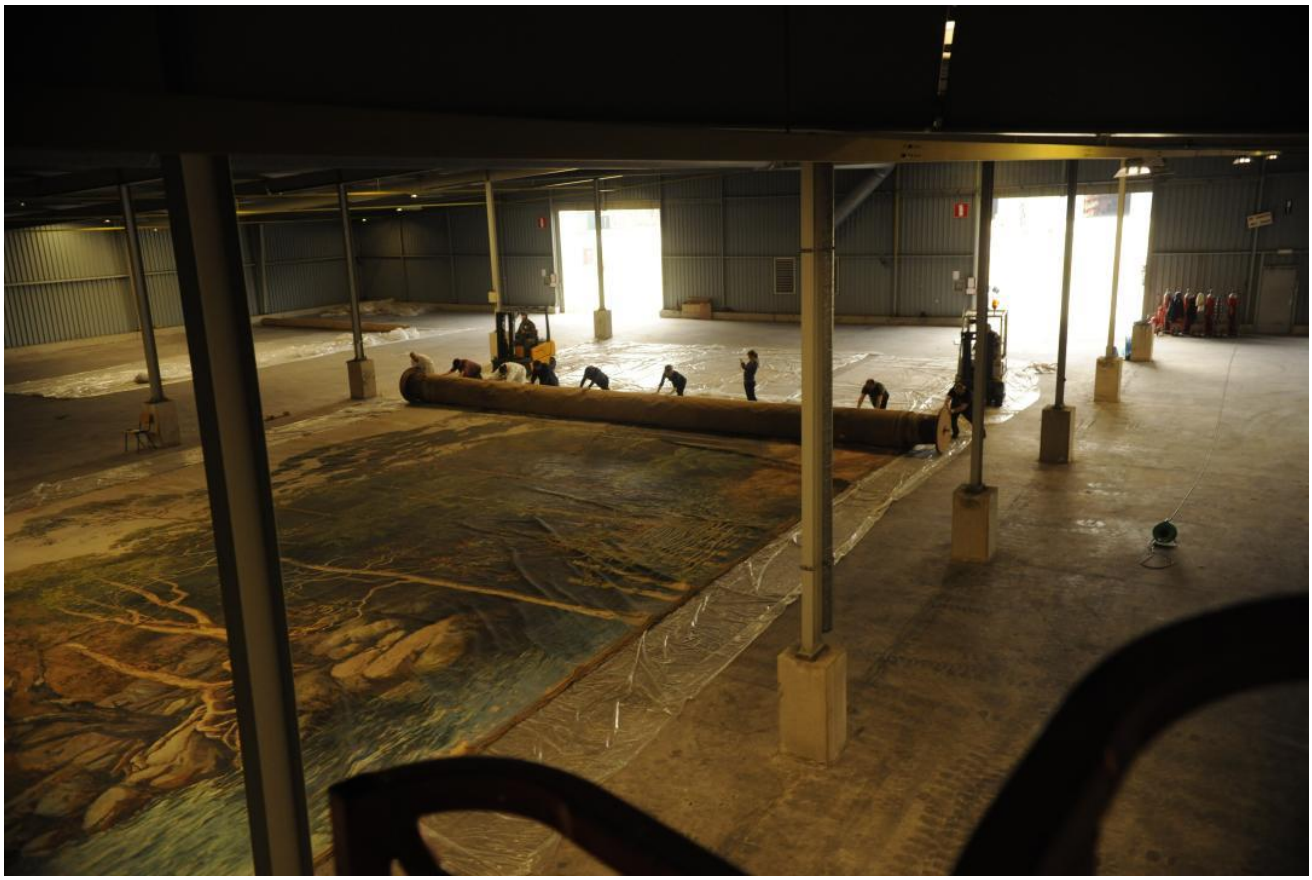


Figure 2: The Panorama of Congo - https://warheritage.be/nl/onderzoeksproject-panorama-congo

- Teaser for the digital exhibition: https://vimeo.com/1026581386/26f357a050
- VR-Gameplay example of the CONGO-VR: https://vimeo.com/1026596444

Panometers of Leipzig and Dresden

The Panometers of Leipzig and Dresden (Germany) are 21st -century variants of the original 'rotundas' which were especially made to showcase the painted panoramas. Both Panometers make use of a former round gasometer building to showcase enormous panoramic paintings (+- 27m high and 105m long). Visitors can appreciate the panorama both from the ground floor or by climbing a raised platform in the center of the building. The immersion is supported with sound effects. Next to natural phenomena (e.g. Mount Everest, Amazonia or the Great Barrier Reef), the panoramas often display historical views, such as Dresden 1945, Leipzig 1813 and Dresden 1756, or Ancient Rome.

Figure 3: The Dresden Panometer, depicting a panorama of Dresden in 1756 - https://www.panometer-dresden.de

- Dresden im Barock (1756): https://www.youtube.com/watch?v=D_9mYNzwvVI

Coastal Stories: Understanding and Adapting to Climate Change

A final and more basic example of a panoramic experience is aimed to be viewed from a 2D-display. The application is to viewed as a video and is available on YouTube. Nevertheless, the video is interactive on a very basic level, as viewers have 360° control of the direction in which they look as the video progresses (3DoF). The video is part of the 'Coastal Stories: Understanding and Adapting to Climate Change' initiative (UK), which is aimed at increasing awareness about the impacts of climate change on coastal regions and the adaptive strategies communities can use to cope with these challenges. It emphasizes the need for sustainable practices to address climate risks like rising sea levels, coastal flooding, and stronger storms. It also discusses the importance of integrating nature-based solutions and community-driven adaptation plans to foster long-term resilience against climate risks An audio voice brings a narrative on climate change in coastal areas as you travel to nine different viewpoints along the English coast. At every new viewpoint, text indicates on what site you have arrived. The video is actually a sequence of videos, and not of stills, making the experience original and impactful. The power of such an interactive video with audio overlay is probably even more apparent in a similar video in which you can follow the ongoing excavations at the Roman site of Vindolanda (Hadrian's Wall, UK). The fact that the Coastal Stories video deals with climate change and the adaptation of coastal environments makes it however more relevant for the BLUE BALANCE project.

Figure 4: Coastal Stories interactive panorama video – Zulfiya Hamzaki

- Coastal Stories: https://youtu.be/K1jmAPCXOBE?si=8W1BIVWWvxNArb5-
- Digging Vindolanda: https://youtu.be/atN5nx9oKJw?si=I_rlzcGqq8ojWnQ8

PC-Based VR Tours

A widespread and basic form of low-immersive VR-applications (LiVR), which have been developed from the 1990s onwards, are virtual reconstructions that are viewed on conventional screens or other 2D displays. Such reconstructions can be showcased both on displays in Musea or visitor centers, on desktop or laptop screens for home screening, or on the portable screens of smartphones and tablets.

Gijon Romano

The 'Virtual Tour' of Gijon in the Roman period is a classic example of PC-based VR-Tours. Not only through its content (the Roman Period), but also in its technology. The virtual tour allows visitors to roam through the Roman villa of Veranes (Asturias, Spain). The tour is supported by a narrative voice (also in subtitles) and spherical music. By clicking the highlighted arrows you can walk through the villa and (6DoF). A map in the upper left corner of the screen provides a continuous indication of where in the villa you are virtually situated through a 'you are here' symbol. Additionally, the current line of sight is visualized with a dynamic quarter-circle. Both symbols remind of the symbology used in the Google Maps mobile app, and are thus easy to comprehend. The comparison with today's landscape and archaeological remains can be viewed in an image gallery which is permanently available in the upper right corner. The virtual persons and animals are static and do not interact during the visit.

Figure 5: Virtual Tour in Roman Gijon - https://www.gijon.es/en/turismo/tours-virtuales

- Virtual Tour of the Roman Villa of Veranes: https://documentos.gijon.es/publicas/turismo/gijonromano/

Time Travel to Brittenburg

A noteworthy second example of such a virtual tours are the six virtual reconstruction of Roman fortresses along the Limes in the Province of South-Holland (The Netherlands). The example of Brittenburg in Katwijk is situated along the coast and is the most relevant in this series to discuss from a BLUE BALANCE-perspective. The virtual reconstructions are also explorative in 6DoF, yet the navigation is somewhat less intuitive and straightforward and more restricted to five viewpoints. The map that allows visitors to locate themselves on the site is also scalable and is situated at the right side of the screen. Here as well, a blue quarter circle indicates the current line of sight. The surrounding (coastal) landscape plays a more important role in this virtual world, which is exemplified by the fact that only one of the viewpoints is situated inside the fortress, and the availability of a bird's eye view. The importance of the surrounding landscape is also highlighted by the permanent availability of comparing the reconstructed virtual landscape with the current landscape through a slider at the bottom of the page, at every location (except the bird's eye view), and in 360°. However, supplementary historical information is less integrated and available, and can only be opened by clicking the 'information' symbol in the upper left corner of the screen. The virtual humans and animals are static and the visit is not supported by audio (narration nor soundscapes).

Figure 6: Virtual reconstruction of Roman Brittenburg - https://geschiedenisvanzuidholland.nl

- Time Travel to six roman fortresses along the Limes: https://geschiedenisvanzuidholland.nl/thema-s/timetravel/locaties/

The Dress and the Shipwreck: an interactive dive

A remarkable and original variant of such a VR-tour, specifically adapted for desktop or laptop use is the interactive dive towards a shipwreck in the Dutch Wadden Sea (the so-called “Palmwood”-wreck in Texel, The Netherlands). The experience is controlled by the scroll-function of a computer mouse and as such functions as a long ‘scroll-through’ VR-tour. The tour starts in the air from a bird’s eye view at 1800m above sea level of today’s coastal landscape. As you start scrolling, you descend towards the sea. On the left side of the screen, a linear height indicator monitors the elevation. In this first part, there is no possibility the navigate autonomously and you can only scroll. As soon as the descent starts, an audio voice with subtitles guides you through the tour. A small progress bar at the top of the screen indicates the length and progress of the audio fragment. The audio fragments are linked to a certain scroll zone. As soon as you enter an (invisible) zone, the related audio starts playing, as soon as you leave the zone, the audio fades away. Before you arrive near the sea level, the present seascape partially fades into a historical seascape, with dozens of ships. Next, you arrive at the vessel from which divers explore the seabed and you become a diver yourself. The audio-voice addresses you as a diver (persona) and you gain more control over the line of sight with a 180° freedom. Further scrolling takes you to the underwater diving experiences. The relevance height indicator on the left side becomes more clear now. Once at the seabed, the indicator turns into a progress bar that indicates your progress in the discovery of archaeological finds. The tour becomes more interactive in this underwater part: you can answer question and receive extra information and you can click on several finds and discover them in a separate 3D manipulation.

Figure 7: The most important find of the dive: the dress - https://duikmee.dejurkenhetscheepswrak.nl/

As you resurface, visitors time travel to the past, visualized by a clock that counts back from 2024 to 1660 and the simultaneous reassembly of the remnants of the ship into the vessel it was just before it was shipwrecked in a storm. This tour is a good example of an application in the creation of certain atmosphere and the storytelling prevail, and where largeness of the virtual environment (LoS) impacts the level of detail (LoD). Although the virtual humans, animals and objects are not as static as in the above examples (improving the immersive aspect) the overall detail of the virtual environment is less elaborated.

The VR-Tour is somewhat misleadingly branded as Online Game and is part of threefold public outreach program. The other two productions are a four-part podcast and a three-part documentary.

- Interactive dive to a shipwreck: https://duikmee.dejurkenhetscheepswrak.nl/
- Link to the podcast: https://open.spotify.com/show/7CpNDseyWQVFJlxiPMLQkd?si=f5703e9e121c433b
- Link to the documentary: https://npo.nl/start/serie/de-jurk-en-het-scheepswrak/seizoen-1/de-jurk-en-het-scheepswrak_1/afspelen

Figure 8: Digital reconstruction of the dress for the podcast and documentary.

AR on location

AR glasses

AR tour in Pompeï

Since 2019, the AR experience at Pompeii Archaeological Park (Italy) enhances the exploration of this ancient city by overlaying digital reconstructions onto the ruins. Using an AR-experience developed by of ARtGlass, visitors can see Pompeii as it appeared before the eruption of Mount Vesuvius in 79 AD. Visitors wear lightweight, easy to wear, and intuitive glasses with the high-resolution displays. An importance difference with AR experiences using mobile devices such as smartphones or tablets (see next example) is the hands free aspect. Visitors only have to turn their head and focus on a specific item, and the holographic images appear promptly overlaid onto the real world. Once they move on to another area, GPS-technology prompts new AR objects onto the new location. Visitors can both individually visit the site, but also have a synchronized group experience in which groups all see the same content and hear the audio guide's narrative simultaneously. A major advantage of this application is that visitors can always observe the real world and more easily navigate the site. A notable example, and in our perception today's most state-of-the-art variant of this application, is the AR experience in focused on the Ghent Altarpiece, in Saint Bavo's Cathedral in Ghent (Belgium), developed by Alfavision in 2021.

Figure 9: Augmented vist of the Saint Bavo Cathedral in Ghent - Alfavision.com

- Promotional video of the AR Tour in Pompeï: https://vimeo.com/492845236
- Promotional video of the AR Tour in Ghent: https://www.alfavision.be/media/oembed?url=https%3A//vimeo.com/635183221/66304d1e83&max_width=0&max_height=0&hash=Z2m-T7diyaiTTn-UHTYhtIe1wbEK_5i9I7Q2M_mNpH4

Mobile device

Aqua Granda – A digital Community Memory

The 'digital community memory' that Aquagranda project (Venice, Italy) aims to build is a digital information resource that is created by a community for the community itself. It is inspired by a human memory, which contains a huge set of facts, images, sounds, smells, bodily experiences, beliefs, commentaries, opinions, speculations, plans, emotions, perspectives and much more. They advocate memory is crucial to give us a sense and purpose and to deal with new experiences based on what we learned from the past. A digital community memory aspires to do the same, except that it is not the memory of a single person but of a group of people who have common concerns. The Aqua Granda project revolves around the memories and traumas of the inundations in Venice in 1966 and 2019. The relevance for BLUE BALANCE is threefold. Not only is the topic of flooding pertinent, also the objective to gather, store, process and display the reactions of citizens, visitors and experts to make opinion about interventions to avoid future catastrophic flooding is valuable. Finally, also the use of advanced digital and AI-tools aligns with BLUE BALANCE objectives (see also 'community engagement' for extra contextualization). One of the specific project outcomes was an application in Augmented Reality developed by artist Joeri Bultheel. The app allows to simulate rising water levels around the city of Venice. This place-based confrontation with the impact of floods and exactitude of specific water levels promises to more effectively help visitors to imagine the impact of rising water.

Figure 10: Augmentedly raised water level (121cm) at San Marco in Venice.

- Video of the AquaGranda project; VR App from 0'36'':https://youtu.be/x2jjlqKH4II?si=kcHPRvB2qGqCCR71

VR with HMD - not on location

VR Dikes

In the context of largescale infrastructural work on the Markemeerdijken (The Netherlands), which protects the area between Hoorn and Amsterdam, the environmental engineering company Witteveen+Bos developed a twofold VR-application to engage all involved stakeholders in the future development of the area.

A first application was aimed to transparently communicate the different possibilities or scenarios to all stakeholders involved: from engineers to inhabitants. Applying the 'Joint Fact-Finding' process, in which separate coalitions of scientists, policy-makers and other stakeholders with differing viewpoints and interests work together to develop data and information, analyze facts and forecasts, and develop common assumptions and informed opinions, VR-technology was used to quickly multiply and alter the amount of possible variants with minor adjustments. Thus, VR was used to create a level playing field for experts, who draw a cross-section of a dike every day, and laypeople for whom making adjustments to a dike is a once-in-a-lifetime experience. As such, the tool facilitates straightforward and understandable communication about the plans and their consequences, preventing misunderstanding and resistance. Especially this last aspect, makes it very relevant for the objectives of BLUE BALANCE.

Figure 11: Projecting different dike-variants in VR - Witteveen+Bos

- Instruction Video: https://youtu.be/LT16nJ61lrE?si=mQsdTROUpAqlyLsm

The second application is exclusively aimed at a non-expert audience and was installed at the exhibition 'Dijk in uitvoering in Katwoude'. Visitors were invited to step into the basket, which was physically present, of a hot-air balloon, and make a virtual flight over the 33km-long project area. The VR experience was rather passive as visitors could not interfere in the flight direction. Minor interactions were included by allowing to switch between the 'current' and 'future' view of the virtual landscape. Audioscapes of passing birds aimed to increase the immersive aspects of the application. At specific locations, visitors can virtually exit the balloon and take a walk on the future dikes. Although this a single-person individual experience, other visitors could follow the flight on separate screens. This application is a another good example of a project in which the storytelling prevails and where largeness of the virtual environment (high LoS) impacts the level of detail (low LoD).

Figure 12: Visitor in a virtual balloon flight over the landscape - Witteveen+Bos

- Video of the VR-flight: https://youtu.be/9dVnbAemrO4?si=sHLGF5kJOuHFrEiy

Drowned Village Scheldeoort

In 2021, the Royal Netherlands Institute for Sea Research developed a virtual reality application for the (then still aspiring) Schelde Delta Unesco Global Geopark. The reconstructed virtual world comprised a fictive 16th-century

harbour village along the Eastern Scheldt (The Netherlands). The topography consisted of both the village and the surrounding landscape and encompassed three different time layers. First, the village and its surroundings can be visited in its 'medieval' setting. Visitors arrive by boat from the main river and dock in a small tidal harbour. Next, they are welcomed by the mayor of the village on one of the dikes that embanked the landscape and are invited to take a walk through the landscape. The application is 6dof as you can move around and look around in 360°, but you are limited to follow a predefined route. Pop-up 'information signs' allow to gain more specific knowledge on certain building or landscape features. The second timeframe is set on 'the day after' one of the largest floods in the area: the Saint-Felix Flood of November 5th, 1530. The complete landscape is now flooded and you navigate through it by boat. Drowned sheep, people on roofs and destroyed buildings further illustrate the catastrophic event. The third timeframe reconstructs the late-16th-century landscape, in which large parts of the drowned cultural landscape are not reclaimed and are left to erode in the tidal landscape. People are adapting to the new ecosystem: villages that are deserted are slowly eroded and covered by sediments, where possible people are recovering the brick from old ruins and the local fishermen are developing new fishing techniques on the large sandflats. This tripartite chronology, in which the 'old situation' is followed by a catastrophic event and eventually by the visualization of the long term impact - including strategies of adaptation and resilience - is of specific relevance for the BLUE BALANCE project, which also aims to visualize different time frames, including the impact of catastrophic events.

Although the virtual worlds can be visited remotely from a desk- or laptop, which makes it also a PC-based VR tour (see above), the application also has a functionality that allows to activate a simulated WebVR Mode with headset tracking. As such, mobile phones can be inserted in a Google V1 carboard VR head mound to ensure a more immersive experience. This was also possible in the local museum.

The VR development was later furthered with the development of a virtual reconstruction of the (non-fictive) village of Wemeldinge around 1150. Because this timeframe depicts the area before large scale embankments transformed the natural tidal landscape, it is a valuable addition from landscape-chronological point of view. In this specific application, the developers chose to increase the 'sense of place' (because they were working in within an existing topography) by adding a modern topographical map and indication of the exact route you are following in the virtual tour. Similarly, integration of the WebVR Mode allowed to visualize the 3D in immersive mode, yet in this case on the location itself, while walking in the current landscape (see also next paragraphs).

Figure 13: Screenshot from the drowned and deserted church of Schelderoort - https://www.zeeuwsetijdreis.nl/verdronkendorp/flat/

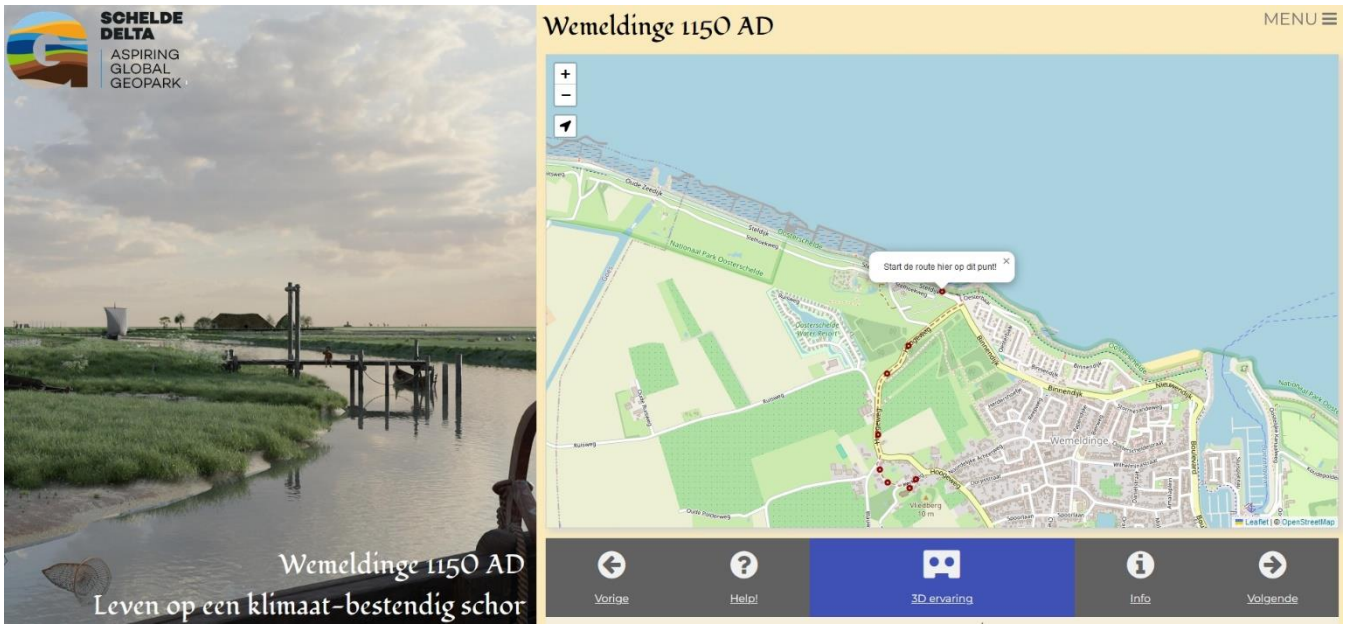


Figure 14: Screenshot from the map-supported tour in medieval Wemeldinge.

- VR tour Scheldeoort: https://www.zeeuwsetijdreis.nl/verdronkendorp
- VR tour Wemeldinge: https://zeeuwsetijdreis.nl/wemeldinge/

VR tour on location

In the category of on-site VR-applications, the device that shows the virtual world can vary. More immersive applications typically rely on head-mounted displays (HMDs), while mobile devices like as smartphones or tablets are often chosen for their lower infrastructural costs. When an HMD is fixed to a sturdy pedestal, visitors are physically restricted to a predefined location on the site, though virtual movement (6dof) can still be incorporated within the VR-experience. In contrast, mobile HMDs theoretically allow visitors a greater freedom to explore a heritage site, yet this physical mobility is not always fully utilized.

Static HMD

Rives de Seine

Along the banks of the Seine river in Paris (France), the Paris based-company Timescope placed one of their first VR-experiences that can be viewed through their inhouse-developed static outdoor VR-terminal. These terminals are originally produced to provide 24/7 on-site outdoor VR-experiences and are manufactured with a robustness to resist weather and mistreatment. The VR-experience along the Seine reconstructs the Place de Grève in 1628 and its immediate surroundings. A scripted voice-over contextualizes the scenes with audio. At this moment, the company is expanding on this VR-experience by developing an entire tour using mobile HMD's (see also next).

Figure 15: The Timescope terminal on the banks of the Seine - www.timescope.com

- Teaser video of the VR experience: https://youtu.be/lQv8bc_J3HI?si=xubRVZbEzAgVKO0d

Mobile HMD

Domus Aurea

A first and forerunning example of on-site use of mobile HMD has been developed on the archaeological site of Domus Area in Rome (Italy). Since 2017, visitors are able to discover parts of the site in virtual reality. The use of virtual reality in this case offers significant advantages, particularly by allowing visitors to better visualize the size, brightness, and openness of the site as it was during the Roman period. This technology overcomes the challenges posed by the site's current underground location, which diminishes the immersive experience and sense of place during a physical visit. While mobile head-mounted displays (HMDs) allow for mobility, visitors in this case remain seated and confined to a single location on-site, experiencing the site virtually. In practice, the mobile HMDs function as static devices. Although this approach might be seen as a "false" application, it is likely the most common method used in museum and heritage contexts. The primary challenge of true mobility with mobile HMDs lies in the risk of collisions. The following two examples demonstrate efforts to address this issue.

Olympia back in time

On the archaeological site of Olympia (Greece), visitors can rent a mobile head-mounted display with audio guide to visit the site individually (i.e. self-guided). At the most important monuments, such as the Temple of Zeus or the Statue of Zeus, VR reconstructions allow to imagine what the site looked like in its prime. The glasses also include a virtual map to navigate and locate key monuments. The system is also equipped with GPS-triggered audio-guide, automatically starting stories and explanations about each monument as visitors move through the site and approach landmarks. The guide is available in seven languages, making it accessible to a wide audience. When launched in 2021, self-guided and GPS-based VR- and audio tour was an innovative application of immersive VR-heritage experiences.

Notre Dame Eternelle

Today, the rebuilt Notre Dame (Paris, France), among many other sites and monuments, also offers a VR-tour with portable HMD. In this specific application, small groups of visitors (1-5 persons) are guided by a virtual avatar, who is visible in VR and audible through audio-support. Visitors are recommended to keep their HMD mounded for the entire visit. To avoid collision with other visitors, nearby persons are also visualized in the VR as ‘anonymous’ avatars.

Figure 2: Visitors using a mobile HMD in Rome, collectively seated on site - Reuters.

Figure 16: Visitor using the mobile HMD in Olympia, individually wandering through the site - www.olympiabackintime.com

- Teaser video of the VR-visit in Olympia: https://youtu.be/LAp6aFsiTmE?si=9NVP3DtYMQtnNM9a
- Teaser video of the VR-visit in the Notre Dame: https://youtu.be/Nc5MunUbNRU?si=R5hZy6YFIFKqkHjw
- Video coverage of the Domus Aurea on CBS: https://youtu.be/0PNPSR1TdP4?si=YkFHqDEB5AJhCA1M

Mobile Device

The abovementioned PC-based VR-tour of Gijon Romano (Asturias, Spain) also has a mobile sister-application focusing on the Roman city itself. Although the application is branded as a AR-tour, it is technically a mix of AR and VR technologies. It for example uses the location and position of a mobile device (AR), yet completely replaces the real world by its virtual counterpart (VR). The app is activated by scanning physical markers ('beacons') that are placed at strategic historical sites in the city, which, when scanned, trigger visualizations of historical scenes, reconstructions, and interactive elements like 3D objects or character animations. A narrator supplements these visuals with detailed descriptions and historical context, enriching the user experience. Visitors can discover the stories of five key figures from Gijón's Roman past, brought to life through virtual reconstructions and AR-based storytelling.

Figure 17: Gijon Romano AR on a smartphone - www.rtpa.es

- Promotion video of all AR-apps in Gijon, including the AR Romano: https://youtu.be/WpLkjXZiWCY?si=3cCB-IqZOJApLouA

Hologram

A Hanzeatic Cog

A hologram showcase is a (usually) square display case in which an object appears to be floating (also see 3.1 Definitions). By using a special glass plate, a light spot and several screens, an optical illusion is created. The reflection coming from the screens undergoes refraction through the glass plate, after which the viewer's brain perceives this refracted reflection as coinciding with the light from the light spot, which is located in the centre of a display case. This creates the illusion that the object is floating in the heart of the showcase. The hologram display case is particularly suitable for presenting objects that cannot be displayed physically. Such a principle is used in the hologram showcase developed in TijdLab for the IJselkogge (Kampen, The Netherlands) in 2017, allowing the wreck of the IJsselkogge to be shown to the public and viewed from all sides, although this is not yet possible in real life.

Figure 18: The Hologram Showcase for the IJsselkogge wreck - Archeologie Leeft/TijdLab

- Video of the IJselkogge Hologram: https://www.archeologieleeft.nl/archeosuccessen/de-geschiedenis-in-3d/

Immersive walks & trails

The above application leads this report temporarily away from VR application into real world applications that aim to immerse visitors into local cultural heritage through 'animated' walks. This report explores the opportunities, ranging from the digital variant of a map/guide of an archaeological site, over podwalks, into interactive heritage walks.

Pafos Unesco Park mobile app

The Unesco Park at Pafos (Cyprus) developed a 'smart app' that serves as the digital guide through the archaeological site. The application for mobile devices is basically a digital map that is supplemented with images, audio and video to enhance the visitor experience. Technologically it combines an GPS-triggered audio-tour (location-based) with QR codes that can be scanned at specific locations. The application was developed in the context of the Pafos' nomination as European Capital of Smart Tourism in 2023 and was part of a larger digitization project. Additional to the initial development of the Unesco Park app, the concept was expanded to the remained of ancient sites in the area, and expanded with AR-applications and 360° tours.

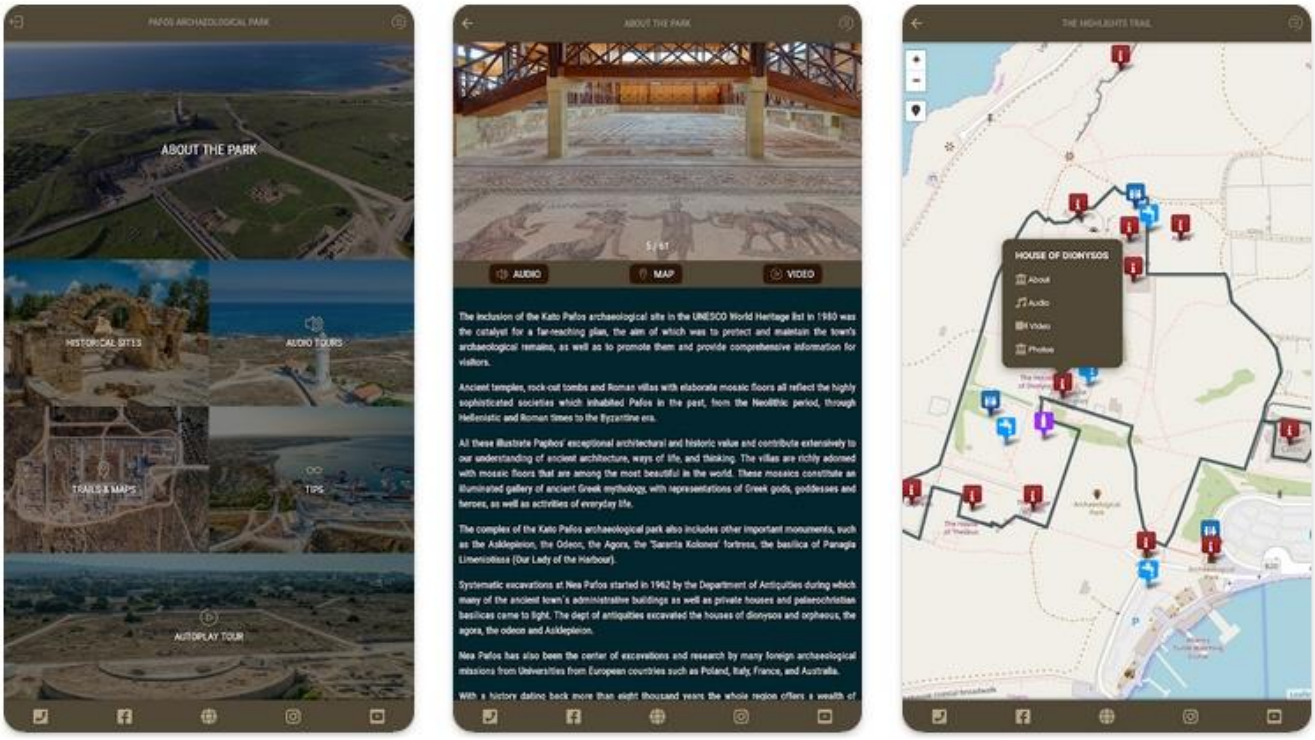
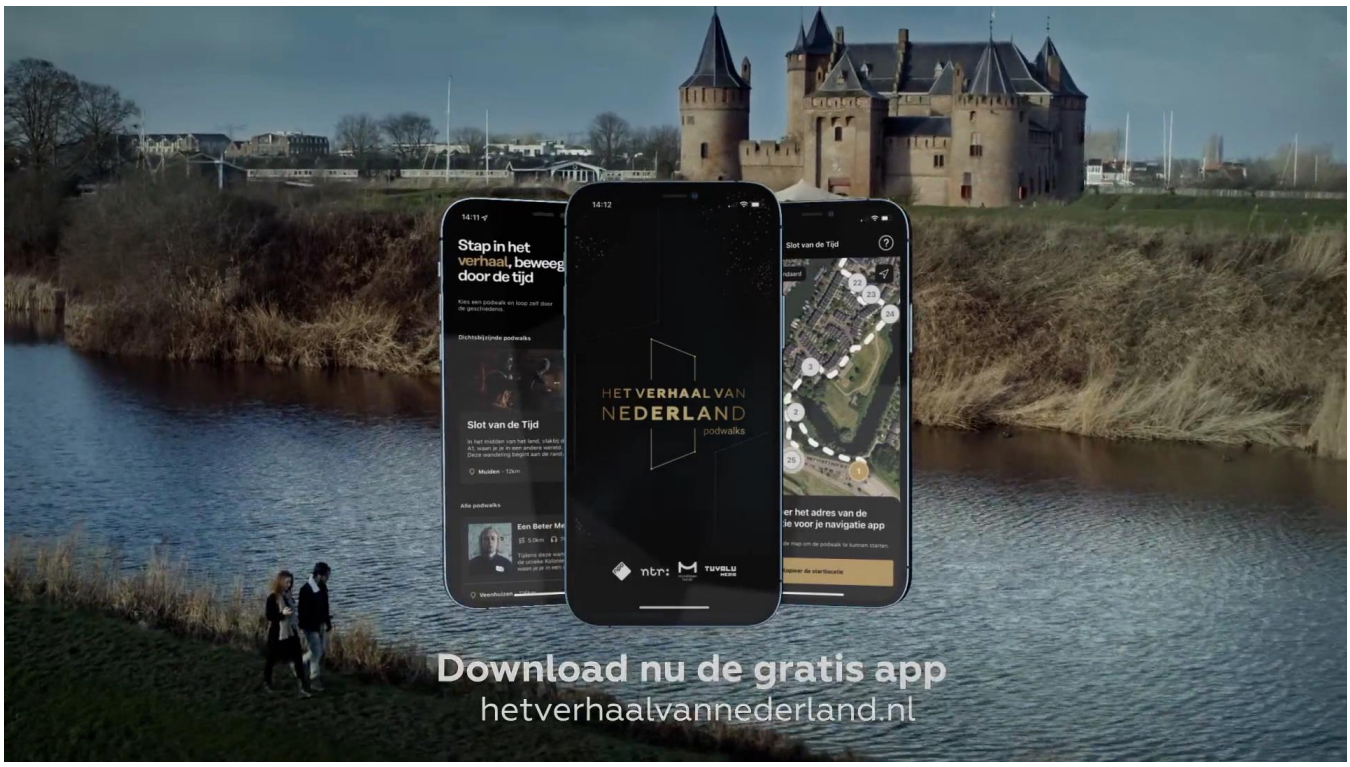


Figure 19: Screenshots of the Pafos Unesco Park Smart App.

Podwalk: het verhaal van Nederland

Podwalks are a specific type of location-based audio-tours. Where the latter are the digital variant of traditional visitor tours, using a more informative and educational tone, podwalks are more related to the format of podcasts, and are, on average, more narrative-driven, including storytelling and ambient soundscapes. The basic common feature , however, is the physical on-site presence of the listener. 'The Story of the Netherlands'-podwalk is a very successful GPS-guided audio tour that covers the history of the Netherlands through 10 stories. The app offers 10 different historical walking routes across various cities and regions in the Netherlands. Each tour is tied to a specific period of Dutch history, from the Ice Age to World War II, with the narration led by actor Daan Schuurmans, who also presented the TV-series from which this podwalk-series is derived. As you walk through these historically significant locations, the app automatically plays audio that connects you with the events that took place there. The GPS feature ensures that you hear the right part of the story as you arrive at various key locations, such as monuments and buildings that played a role in the historical events being discussed. The app also provides additional resources like route maps and downloadable transcripts of the walks, making it both an engaging and informative tool for those interested in the history of the Netherlands.



- Audioteaser for the more maritime-themed Podwalk of Dokkum: https://hetverhaalvannederland.ntr.nl/podwalks/dokkum/

The Maritime Mile

The Maritime Mile in Belfast (Northern Ireland) showcases the city's maritime heritage with a scenic walk along the River Lagan. Spanning approximately one mile (1.6 km), it runs from the Titanic Quarter to the Donegall Quay and offers a range of attractions related to Belfast's historical and contemporary maritime activities. The project was a key part of Belfast's regeneration efforts, blending modern developments with a celebration of its industrial past, particularly the shipbuilding legacy. It serves as both a tourist destination and a recreational space for locals, drawing attention to the city's importance in the global maritime industry. Without application of VR or any digital products, it aims to immerse visitors into the maritime past of the city. Key features of the Maritime Mile include the Titanic Museum and visits to historical ships, such as the SS Nomadic and the HMS Caroline. It are, however, the smaller in-between, architectural elements (such as the Great Light lighthouse, the Seaman's Church, or the illuminated Titanic shipyard), exhibits (such as the RiverBox, the Where Belfast Begins Storyboxes), and artworks (such as the Soundyard or The Big Fish) that make it stand-out as an immersive (maritime) route. The maritime heritage is thus used as the backbone of a broader socio-economic regeneration of the harbour area and intertwined with other touristic aspects such as food and accommodation.

Figure 20: The Big Fish as part of the Maritime Mile in Belfast – www.maritime-mile.com

- Promotional video of the Maritime Mile: https://youtu.be/pcWOEisN5Z0?si=gY_vEU6xoIqNrOAM

Games & Play

RoMeincraft

RomeinCraft is an innovative example of an immersive heritage application that leverages the popular video game Minecraft to engage audiences in exploring Roman history and culture. This project uses the game's open-world, block-based environment to recreate historically accurate Roman landscapes, buildings, and infrastructure, blending entertainment with education. RomeinCraft allows participants to interact with historical reconstructions in a virtual space, fostering a deeper understanding of Roman urban planning, architecture, and daily life. The *Minecraft* platform transforms static representations of heritage into dynamic, experiential environments, making the past accessible and engaging. Moreover, the project embodies the principles of co-creation by involving players, educators, and heritage professionals in the process of designing and populating Roman worlds. By utilizing Minecraft, RomeinCraft bridges the gap between advanced digital heritage techniques and mainstream gaming technology. This balance between "high-tech" fidelity and accessible tools exemplifies a "low-threshold, high-ceiling" approach—inviting novices while still providing depth for experts. Also, by tapping into the existing *Minecraft* player base, RomeinCraft reaches a younger, digitally native audience, a target audience which is otherwise more difficult to reach or engage with. Next to the building activities of the game, players could also visit the virtual worlds they build with 6dof HMD-experiences.

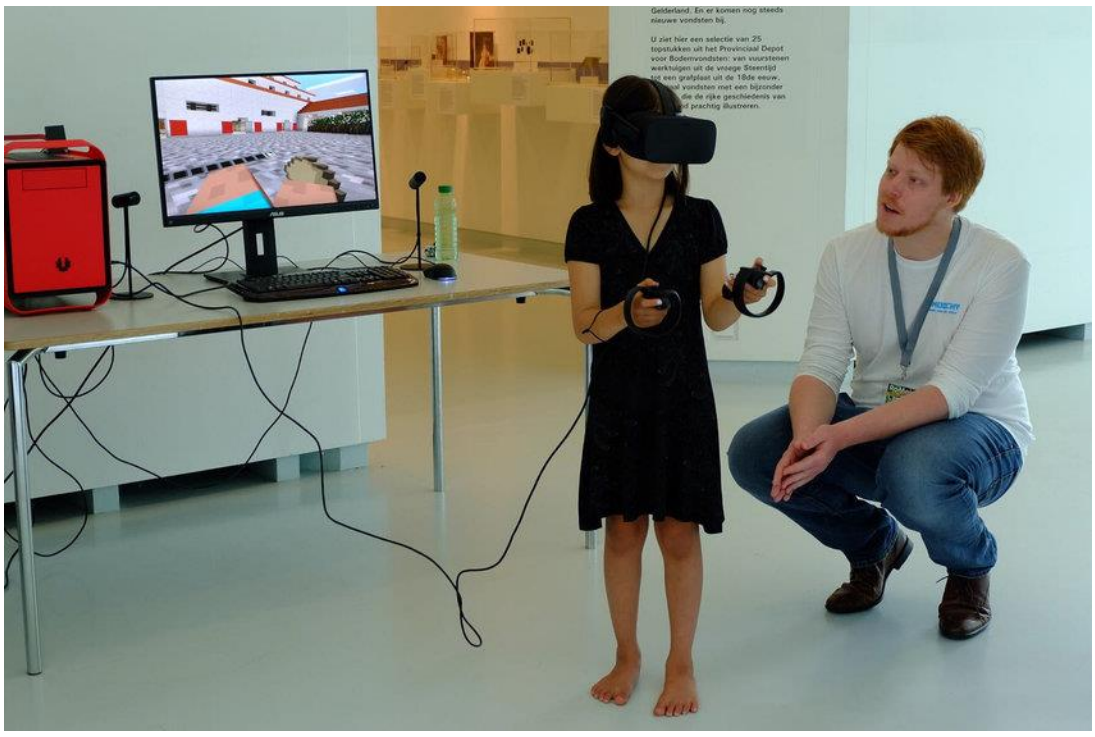


Figure 21: VR-visit of RoMeincraft - DOI: 10.5334/bch.c

- RoMeincraft teaser video: https://youtu.be/o7ySDorUEs4?si=dMBuk8PyjTpObEpt

Vindolanda Games

Based on the excavations on the Roman site of Vindolanda (Northumbria, UK), two games were developed by the Vindolanda Charitable Trust: 'The Missing Dead App' and the 'Vindolanda Adventure'. Both digital experiences aim to transform the archaeological findings and historical narratives of Vindolanda into engaging and educational gaming environments. The Missing Dead App is conceptualized as a (whodunit) murder mystery set in Roman Vindolanda, where players unravel the secrets of a crime by piecing together archaeological and historical evidence. Players take on the role of an investigator, engaging with the site's historical context through a fictional yet plausible narrative. By solving puzzles and analyzing clues, the historical content is gamified, fostering a deeper understanding of the Vindolanda site and its significance. The Vindolanda Adventure is a game designed to immerse players in the daily life of Roman Vindolanda, allowing them to take on roles such as soldiers, scribes, or traders while completing historically inspired tasks. Thus, it applies role-playing mechanics with associated tasks, such as writing tablets, maintaining defenses, or trading goods.

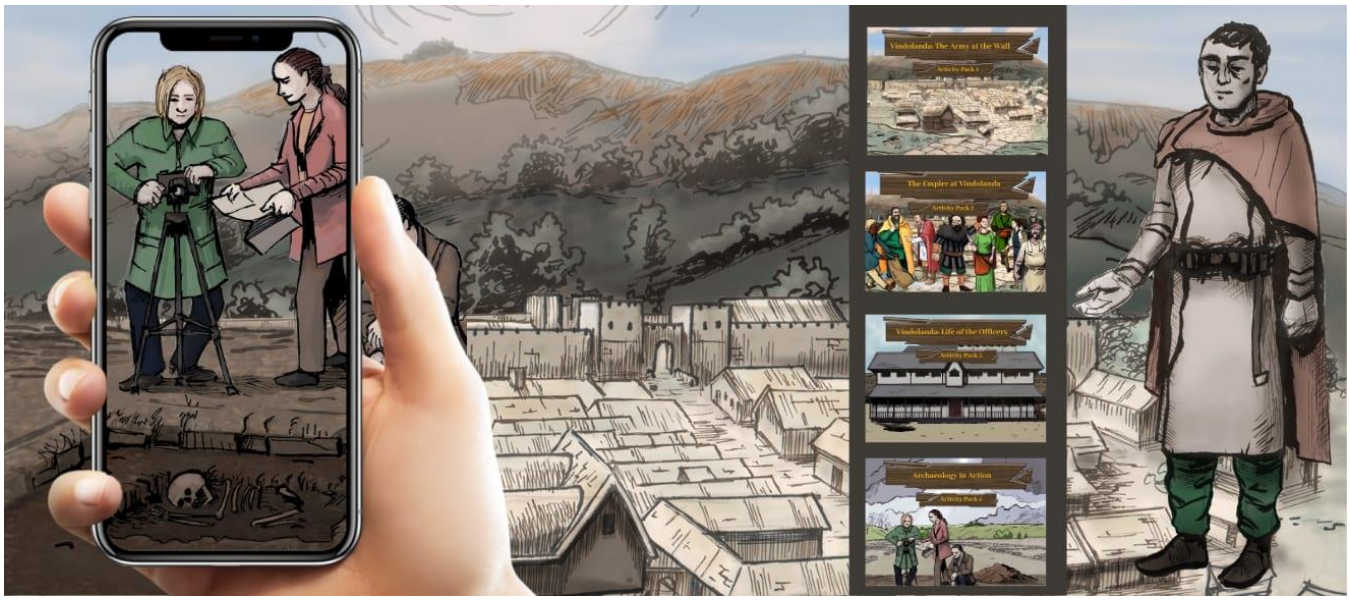


Figure 22: Screenshots of The Missing Dead App – www.vindolanda.com

- The Making of the Vindolanda Adventure: https://youtu.be/tm50KalKwx4?si=Cb7q6MMbY9oeuSuK

Location-based theater

Grens/Limes

The Grens/Limes theater, first performed by the Dutch 'Nieuw Utrechts Toneel' in 2018, is an example of immersive heritage experience, intertwining theater, storytelling, and historical exploration. The production brings the historical Roman Limes, the frontier of the Roman Empire in the Netherlands, into contemporary cultural and personal narratives. This location-based theater evokes immersion through its specific (outdoor) setting: the performance itself is taking place in evocative locations along the Roman Limes, leveraging the historical landscape as both a backdrop for and an active participant in the storytelling. The choice of authentic or historically resonant spaces fosters a deep connection between participants and the ancient frontier. The "Grens" (frontier) metaphorically explores boundaries in history, culture, and personal lives, reflecting on how borders influence identity, belonging, and conflict. This thematic blend of past and present invites audiences to reflect on their own relationships with borders and heritage. By transforming the stage (a limes/line) into a long dining table on which a Roman diner is served after the performance, the theater adds a powerful layer to its immersive heritage experience. Combining performance with a shared meal is a multi-sensory activity which deepens the connection between participants, the narrative, and the historic setting.

Figure 23: Screenshot from the theater during the performance: the long table serves as the red limes, the stage and the dining table.

- Trailer of the Grens/Limes theater: https://youtu.be/0B25efNbMUY?si=z1hWKuGxxm2zDqjy

Community Engagement

Re-enactment

Guédelon Castle

A specific type of community engagement is the combination of experimental archaeology with re-enactment, which has high immersive qualities for both the re-enactors and the visitors. One of the most famous and long-lasting projects is the Guédelon Castle Project in Burgundy (France), where artisans and volunteers are constructing a medieval-style castle using only 13th-century techniques, tools, and materials. The project recreates medieval construction methods, allowing researchers to understand historical craftsmanship and problem-solving. The hands-on, real-time experimentation helps to test historical hypotheses about building techniques. Guédelon invites the public to observe and engage with artisans at work, including stonemasons, blacksmiths, carpenters, and roofers. Visitors experience history in action, fostering a deep connection to medieval heritage. The project also emphasizes the use of local materials, such as wood, stone, and clay, aligning with the principles of sustainability while demonstrating medieval logistics and environmental adaptation. With a year-round participation of re-enactors (peaking to 50 to 70 craftsmen in summer) and more than 300.000 visitors annually Guédelon has become a popular tourist attraction and has inspired similar projects worldwide, becoming a model for blending hands-on archaeology with public engagement and education.

Figure 24: Aerial View of the builing of Guédelon.

- Video coverage of Guédelon on NBC : https://youtu.be/Kg9EebAjpGc?si=vuPIMh7-8a6eyO31

Roskilde Viking Ship Museum & Gravelines Espace Tourville

Two more maritime-inspired project are worth mentioning here: the historic shipbuilding sites of Roskilde (Denmark) and Gravelines (France). In Roskilde, the Viking Ship Museum has initiated a historic shipyard in which the locally excavated Viking ships are reconstructed. Visitors can participate in workshops, sail on reconstructed ships, and observe the building processes. A similar, yet more small-scale and less participative project has been launched in Gravelines, where the Espace Tourville is dedicated to the construction of the Jean Bart, a monumental 17th-century warship from the era of Louis XIV. The project is engaging visitors by demonstrating traditional shipbuilding techniques, with marine carpenters and blacksmiths working in full view. Visitors can experience the ongoing construction of this historical ship as well as explore the broader maritime heritage of the region.

Figure 25: One of the reconstructed Viking ships in Roskilde.

- Website of the Roskilde shipyard: https://www.vikingeskibsmuseet.dk/en/professions/boatyard
- Website of Espace Tourville: https://espacetourville.com/

Citizen Science

Heritage Quest

Heritage Quest (also known as Erfgoed Gezocht) is an innovative citizen science project based in the Netherlands that focuses on discovering and preserving archaeological heritage. The project is significant for involving the public in research, enabling volunteers to actively contribute to archaeological discoveries. By combining new technologies such as high-resolution LiDAR maps and traditional fieldwork, participants have uncovered thousands of previously unknown archaeological sites, including prehistoric burial mounds, Celtic fields, and charcoal kilns, primarily in regions like the Veluwe. The project enhances public engagement by empowering participants to directly assist with mapping and validating these hidden structures, fostering a deeper sense of ownership and awareness about cultural heritage. This participatory approach has not only resulted in the discovery of critical archaeological sites but also contributed to scientific progress, such as the use of AI to automate the detection of archaeological features from remote sensing data. Like the immersive and participatory approaches seen in other heritage projects, *Heritage Quest* emphasizes active involvement and local community engagement in the process of safeguarding cultural heritage. Its impact is reflected in the strengthening of local identities and a broader appreciation for historical landscapes, making it a notable example of combining modern technology with public participation in heritage conservation.

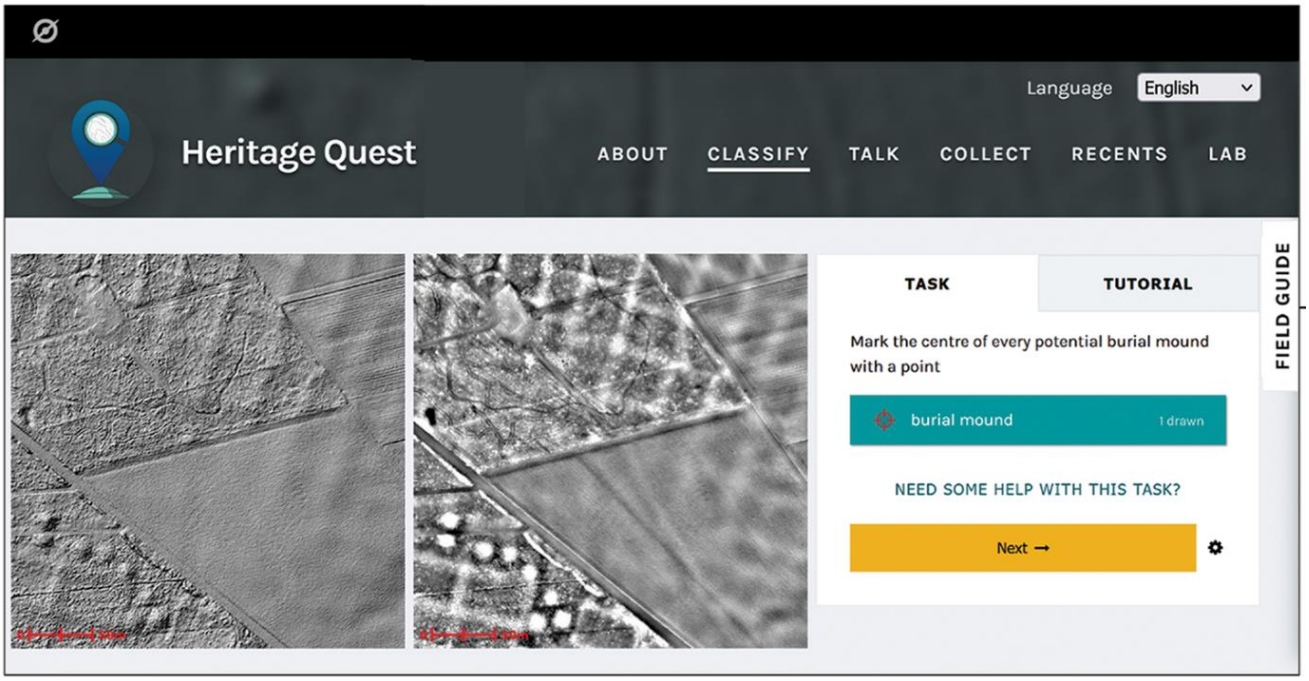


Figure 26: Screenshot of the digital platform of Heritage Quest - doi:10.15184/aqy.2024.127

- Website of Heritage Quest: https://www.zooniverse.org/projects/evakap/heritage-quest
- Project video for Europa Nostra: https://vimeo.com/738249944

Participatory Storytelling

Urban Belonging & Aqua Granda

Another type of community engagement employed in the Urban Belonging Project (Copenhagen/Amsterdam) and the Aqua Granda initiative (Venice), as they share a similar as participatory and immersive heritage approach that use innovative methods to engage communities, preserve cultural narratives, and foster a deeper understanding of cultural landscapes. Both projects prioritize personal experiences and community-driven storytelling and apply digital platforms to do so. Urban Belonging collects stories about urban inclusion and identity, while Aqua Granda records residents' experiences of the catastrophic 2019 floods in Venice. Whereas Urban Belonging uses a photo app and participatory mapping for emotional geographies, Aqua Granda leverages multimedia archives and an interactive digital platform to document the flood's impacts. Both initiatives explore the connections between people, heritage and their environments and employ those connections to address contemporary challenges, such as social sustainability in urban communities, or climate change for cultural heritage. The applied approaches and specific focus on the evolving relationship between people, places and heritage can be of particular relevance for a coastal variant along the Flemish coast.

Figure 27: Flyer of an activity within the Aqua Granda initiative

- Project website of AquaGranda: https://www.aquagrandainvenice.it/en/about
- Project website of Urban Belonging: https://urbanbelonging.com/

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