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Title: ***e-Archeo*: a sustainable and multichannel project for the multimedia and virtual valorization of 8 Italian archaeological sites, combining scientific approach, emotional dimension and new technologies.**

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Abstract:

Commissioned to ALES spa by the Ministry of Culture (MiC), the e-Archeo project was born with the intention of enhancing and promoting knowledge of some Italian archaeological sites with a considerable narrative potential that has not yet been fully expressed. The main principle that guided the choice of the sites and the contents was of illustrating the various cultures and types of settlements present in the Italian territory. Eight sites were chosen, spread across the national territory from North to South, founded by Etruscans, Greeks, Phoenicians, natives and Romans. e-Archeo has developed multimedia, integrated and multi-channel solutions for various uses and types of audiences, adopting both scientific and narrative and emotional languages. Particular attention was paid to multimedia accessibility, technological sustainability (Maietti, 2023), and open science.

The e-Archeo project was born from a strong synergy between public entities, research bodies and private industries thanks to the collaboration of MiC and ALES with the CNR ISPC, 10 Italian Universities, 12 Creative Industries and the Italian National Television (RAI). This exceptional and unusual condition made it possible to realise all the project's high-quality contents and several outputs in only one and a half years.

1. INTRODUCTION

1.1. The project

The e-Archeo project (https://e-archeo.it/), realised in 2021-2022, stems from the desire of ALES SpA, on mandate of the Ministry of Culture (MiC), to enhance and promote some Italian archaeological sites with a considerable narrative potential, distributed throughout the national territory.
Centres of Etruscan, Greek and Phoenician Punic and indigenous culture have been chosen and each of them has been represented and narrated in its main stages of development, through the illustration of the best-preserved monuments.
Sirmione and Desenzano, Marzabotto, Cerveteri, Alba Fucens, Velia, Egnazia, Sibari, Nora are the eight sites from North to South Italy that have been chosen as symbolic places to tell the story of the beauty and cultures of our country, thanks to Digital and Virtual Reality, with particular attention to technological sustainability and accessibility to Cultural Heritage.

The monuments were presented in their current state of conservation and as they could appear in the past, through virtual reconstructions aimed at restoring their third dimension lost over the centuries.
Places of public life (forums, basilicas, temples) and private life (urban dwellings and villas) have been selected for narration, as well as the necropolis with tombs and grave goods, mirroring beliefs in the afterlife.
The chronological span considered covers more than ten centuries, during which time the peninsula became a place of integration, where different traditions were connected in a unified culture under the Romans.
The relationship of each site with the territory and with the major trade routes (sea, rivers, roads, etc.) was also highlighted: In fact, in addition to the monographic view, focused on individual buildings or contexts, great importance was given to the holistic view, and for the first time virtual reconstructions on a landscape scale were attempted.

The focus of e-Archeo was to create an integrated and multichannel multimedia project for cultural valorisation, with transversal solutions for all the sites, including digital applications for various uses and types of audiences as final outputs (Pietroni et al., 2023).

1.2 Partnership

The main objective of the e-Archeo partnership is to strengthen the capacity of government institutions, research organisations and creative industries to work together in the valorisation of the Italian cultural heritage, sharing ideas and developing innovative and efficient working methods. A new synergical working methodology was developed, and reciprocal transfer of know-how among institutions and companies made it possible to create a project based on sound scientific criteria, and open to creativity and to the diverse needs of the publica. Besides it is grounded on Open Science policy and FAIR principles (Wilkinson et al. 2016).

The Institute of Heritage Science of CNR (ISPC-CNR) was appointed for the multimedia design of the interventions, in collaboration with ALES, and for the coordination of the executive production of all the outcomes, through the identification of audio-visual and interactive formats, the elaboration of methodological guidelines, the organisation of the editorial workflows. CNR ISPC shared with creative companies open-source platforms and operational tools, especially for the e-Archeo 3D web app and for the scientific back-end management, which developed over many years of research, with a specific focus on their sustainability and future reuse.
Finally, it produced some scientific and narrative contents for the Cerveteri archaeological site, where the institute has been carrying out excavation and research activities for many years.

Nine Italian Universities were involved in the e-Archeo project, plus the Italian Archaeological School of Athens.
They helped collection and selection of scientific data already in their possession, from previous projects or research work carried out by in-house staff. They also supervised the multimedia content created by the creative cultural industries that won a public selection.
Finally, they produced some specific content and provided support and advice on topics within their competence.

The Italian National television, RAI Storia, realised documentaries presenting the eight archaeological sites, illustrating their beauty and tourism potential. Eight films that have been transmitted on Rai Storia channel and then integrated in the e-Archeo 3D web app.

1.3 Open Data adoption

All the sources and dataset are interoperable and accompanied by metadata, and, together with methodological guidelines, have been published on Zenodo (https://zenodo.org/) in the e-Archeo community, under *@CreativeCommons licenses,* (https://zenodo.org/communities/e-archeo/records?q=&l=list&p=1&s=10&sort=newest). The results of e-Archeo are therefore reusable, transferable, amplifiable and have a strong transdisciplinary dimension. They can be certainly shareable locally, regionally, nationally and transnationally and they can be re-used for new application the Institutions will be willing to promote, on the sole desirable condition that these are released under the same license.

2. THE ARCHAEOLOGICAL SITES

2.1 Sirmione and Desenzano (Lombardia)

In the beautiful scenario of Garda Lake, the late antique *villae d'otium* of Sirmione and Desenzano where selected, whose development was also favoured by the productive capacity of the surrounding area.
The topics covered by the project are: 1) the relationship with the land and nature; 2) the architecture and residential environments; 3) the mosaic decorations, 4) the personalities who lived in the villa; 5) ideology and daily activities.

2.2 Marzabotto (Emilia Romagna)

With reference to the Etruscan culture of North - central Italy, Marzabotto archaeological site was included. The “new city” of Kainua was founded in the 6th century BC, on a green plateau in the Reno valley, a pivot of the road network between Tyrrhenian Etruria and Po Valley. The shape of the city was a projection of the celestial order.
The topics covered by the project are: 1) the origin of the city; 2) the relationship with the territory and with other northern Etruscan groups; 3) the Etruscan-Italic concept of the city as a sacred and consecrated place; 4) private dwellings; 5) the productive areas and shops for trade; 6) the great temples.

2.3 Cerveteri (Lazio)

Cerveteri has been chosen as one of the best preserved Etruscan archaeological sites, in relation to its necropolises, funerary architecture and ideology, which also allow us to appreciate many aspects of their daily lives.
The topic covered by the project are: 1) the origin and development of the city in relation to the territory; 2) the city of the dead represents the city of the living; 3) the influence of Greek and near-eastern culture; 4) the Banditaccia and Monte Abatone necropolises (the latter one closed to the public, but virtually accessible); 5) the National Archaeological Museum of Cerveteri.

2.4 Alba Fucens (Abruzzo)

Alba Fucens was selected as a valuable example of city founded by the Romans, at the end of the 4th century BC, in the territory inhabited by the Aequi, an Italic people; it was a colony under Latin law.
The topic covered by the project are: 1) the relationship between the site and the landscape; 2) public buildings; 3) the Forum and Basilica; 4) trade, *Tabernae* and the *Macellum, 5)* the people and their daily lives

2.5 Velia (Campania)
In Campania the city of Elea, founded in the 6th century BC by the Phocaeans, a population coming from the coasts of Turkey, was considered. They maintained friendly relationships with the local populations, until the classical times, when tensions with the Lucans would have been resolved with the help of the good laws of Parmenides, originally from Elea. The process of integration of Elena in the new Roman Municipium of Velia was also recounted in the proejct.
The topic covered by the project are: 1) the city's phases and the functional nuclei; 2) the school of physicians and philosophers; 3) springs and thermal hot spring waters; 4) marine activities and lifestyle.

2.6 Egnazia (Puglia)
Egnazia was selected as it was a Messapian city first, and later a Roman city. It is the largest archaeological site in Puglia, near Fasano. Its port was connected to the ancient East-West communication route joining the lower Adriatic to the northern Aegean and Black Sea.
The topic covered by the project are: 1) the city in the Messapian and Roman ages and late Antiquity; 2) the roads and their relationship with the sea; 3) political power and community life, public and residential construction, artisan production; 4) sacred places and the cults, up to the advent of Christianity.

2.7 Sibari (Calabria)
Sibari recounts the story of a splendid city of Greek origin, destroyed and rebuilt for three times. Any trace of the three overlaid cities had disappeared before the Zonotti Bianco's discovery in 1931: Sibari, the original colony founded by the Achaeans and destroyed by the Greeks of Croton, the splendid Thuri refounded by the Athenians and designed by Hippodamus of Miletus in the middle of the 5th century, and Copiae, the smallest colony under Latin law wanted by the Romans. Everything had vanished under a flood layer of up to 6 meters deep.
The topic covered by the project are: 1) the origin; 2) the evolution and form of the city; 3) the temple of the eastern deities at the Casa Bianca.

2.8 Nora (Sardegna)
Nora is an example of Phoenician – Punic city. In the second millennium BC, the Nuragic peoples of Nora encountered the Greeks, Mycenaean and Phoenician merchants. Later, the ancient Phoenician Emporium of Nora became a Punic colony of Carthage. Finally, the Roman conquest brought a greater influx of people from all over the Italian peninsula.
The topics covered by the project are: 1) the origin and development of the city and the territory's resources; 2) Nora's mixed-race ethnicity; 3) the peaceful encounter between peoples and cultural contamination; 4) the form of the city; 5) residential and sacred construction in the Phoenician, Punic and Roman ages; 6) daily life; 7) the necropolis.

3. OUTCOMES

The multimedia applications, aimed at enhancing the 8 archaeological areas, are usable by the public in different ways and at various moments of the cultural experience, both in situ and remotely, through online applications and site-specific installations.
The project provides various levels of representation and narration of contents, various tools and communicative styles to illustrate the different contents: to the scholar it provides all the information to follow the reconstruction process of the various environments (levels of reliability, sources and interpretative processes); to the visitor it provides narratives adopting a more attractive and sometimes dramatised style. Accessibility strategies and Universal Design principles have been applied to allow everyone, including people with visual, hearing and motor disabilities, to enjoy the content, especially in the case of Cerveteri site.
The current archaeological landscape is represented and narrated as it is today, through digital models and movies ("archaeological landscape"); the potential ancient landscape is represented through virtual reconstructions ("reconstructed landscape"); the scientific back-end, supporting virtual reconstructions, has been codified in third rendering layer, where false colours are associated to the various elements of the virtual reconstruction, corresponding to different reliability levels; these latter are also and connected to the interpretative sources and processes that have supported the reconstructions ("interpreted landscape") (Demetrescu and Ferdani, 2021), (Pietroni et al. 2022).
This project has strongly demonstrated how virtual reconstructions are not only a dissemination tool for conveying consolidated knowledge, but also a powerful means of study, simulation and comparison between several interpretative hypotheses, and thus ultimately a tool for increasing knowledge of archaeological contexts. Virtual reality in fact, as a form of visual and organic representation, gives form to abstraction and requires the formulation of precise interpretative choices, consistent with both the archaeological evidence and the cultural and structural patterns of reference (integration of bottom-up and top-down processes). The reconstructive process, in fact, reopened the discussion among experts to the point of finding new shared solutions.
The three-dimensional reconstructions, the scientific back-end associated with them and the narrative content were incorporated into various multimedia applications to enhance the eight archaeological areas to reach the public in different ways, both in situ and online.
The outputs of the project are as follows (fig.1):
e-Archeo 3D;
e-Archeo Voices;
e-Archeo Tactile;
e-Archeo HI—Human Interface;
e-Archeo Video;
e-Archeo Website.
The e-Archeo Website (https://e-archeo.it/) collects the whole project
story, the actors, the methodology and the results. It offers access to all other web apps and to the Zenodo e-Archeo collection.

Figure 1. e-Archeo outcomes

3.1 e-Archeo 3D

e-Archeo 3D (https://3d.e-archeo.it) is an interactive, browser-based application, allowing users to explore and interact with the eight archaeological sites, which can be selected on a map or in a list on the right in the layout (fig.2).

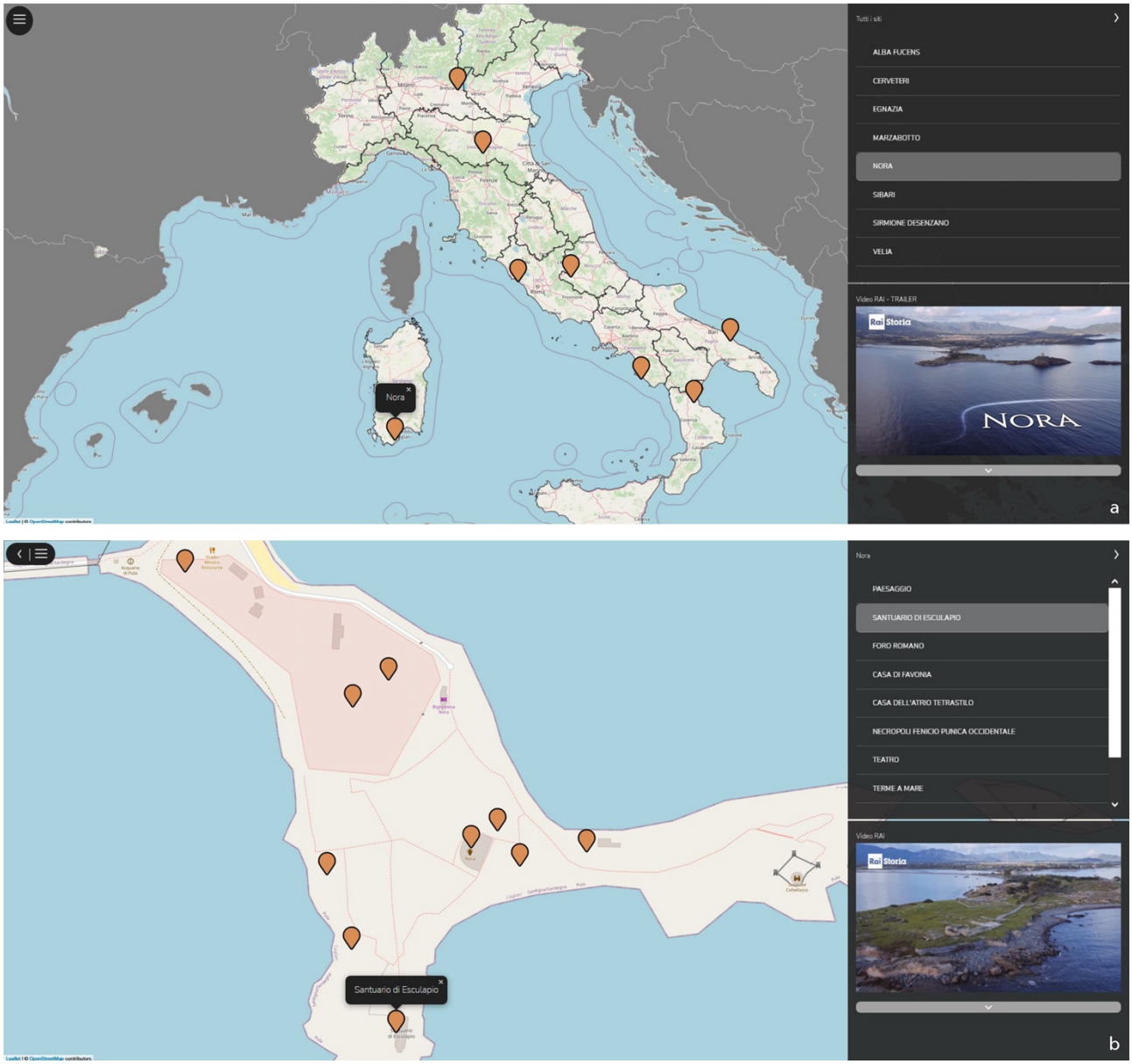

Figure 2: main interface of the e-Archeo 3D web app

Each site is introduced by a documentary realized by RAI Cultura. On the map the main archaeological contexts (a bulging, a necropolis, a temple, etc.) of the selected site are shown and can be entered. Each context can be explored through the time (archaeological, reconstructed and interpreted landscapes).
In the e-Archeo 3D web app, virtual reconstructions are accompanied by a double layer of content: narrative and scientific: in addition to the photo-realistic renderings associated with the storytelling, the scientific “back end” is presented, which confirm the different reliability levels of the reconstructions, and sources (stylistic comparisons, architectural rules, and relevant bibliography) and interpretative processes followed.
The 8 archaeological sites are thereby promoted both scientifically and emotionally, for different target audiences.
In particular in the e-Archeo 3D web app, these visualisations may consist of:

- 360° interactive rendering (equirectangular projection), used especially in specific contexts (building, temple, square, etc.) populated with multimedia contents such as videos,

pictures, audios, and texts;

- simple VR scenes, in case of visualization of museum objetcs, accessible also on common smartphone.
- Movies, used especially for general introductions and landscape reconstructions.

Each archaeological context has several interactive 360° views and the user can jump from one to another one, connecting places in the same area.
In each one 360° view, the user can switch among the three layers, (archaeological, reconstructed, interpreted) that are perfectly overlapping, so as not to cause any disorientation (fig.3). At the same time this tripartition allows users unable to access the real site to have an easier perception and understanding of the archaeological context.

Figure 3: e-Archeo 3D. Egnazia, representation of the market square in different chronological phases: today (top image), Roman time (second image from the top), Late Antiquity (third image

from the top), and interpreted landscape with reliability levels (bottom image).

Each layer, in each 360° view, has a main content introducing the scenario, however, the application of semantic maps to 360° rendering defines, more in detail, meaningful interactive elements in the scenario that can be queried, to go deeper into the contents (fig.4).

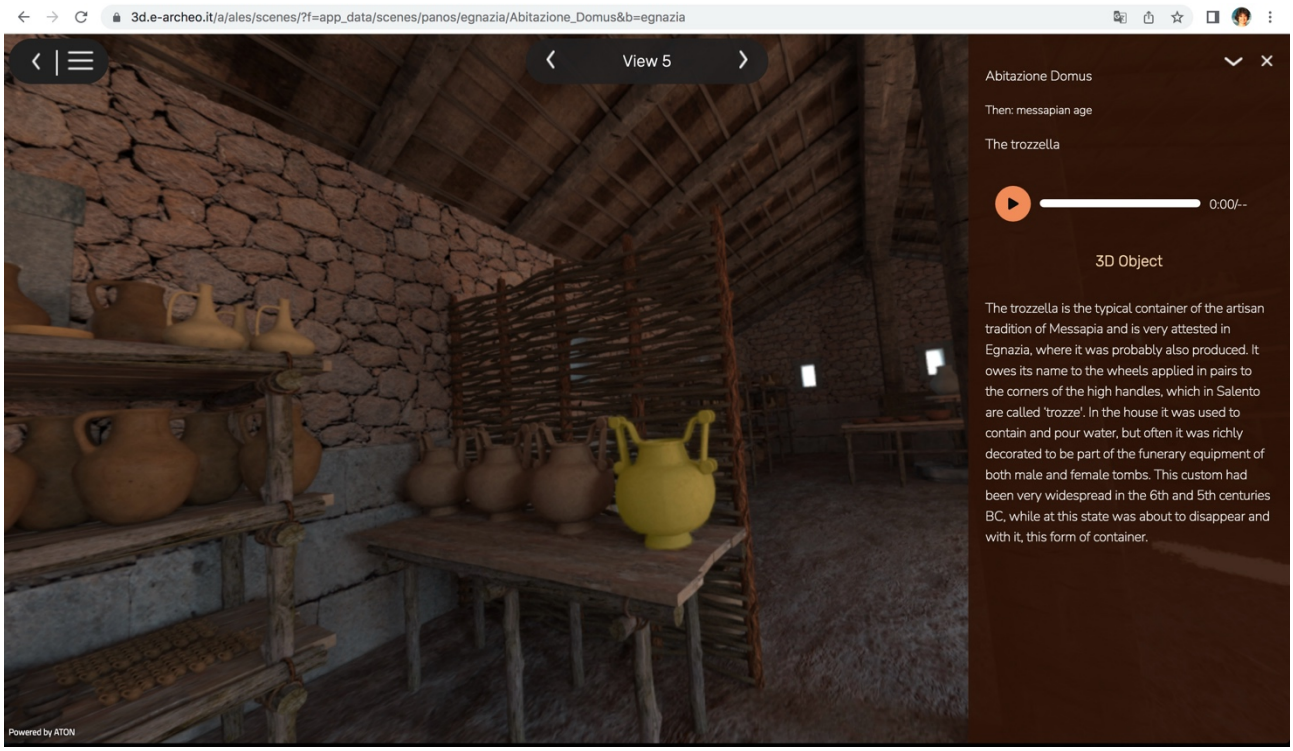

Figure 4. e-Archeo 3D. Virtual reconstruction of a domus, example of interactive elements in 360° scenario

These contents can be accessed through personal mobile devices, and therefore this kind of visualisation breaks down problems of technological compatibility, computational overhead, complexity of interfaces, user disorientation and consequently loss of motivation.
It is important to consider that the e-Archeo project was started and developed during the pandemic Covid-19 and it was mandatory to adopt to keep as far as possible digital applications on personal devices.
The exploration is designed to be carried out in situ, to have valid knowledge support during a live visit of the archaeological sites, or online, to virtually reach the archaeological site from home or school.
The online platform is fundamental to ensure wide accessibility to the contents and to propose common solutions for eight archaeological sites.
For this purpose, the ATON framework (https://osiris.itabc.cnr.it/aton/), developed by CNR ISPC, was chosen to support the e-Archeo 3D web app (Fanini et al., 2021). ATON is an open-source framework based on large open-source ecosystems, designed and developed to create Web3D/WebXR apps interacting with cultural heritage objects and 3D scenes on the web. It adopts a "develop once, deploy everywhere" approach, without requiring any installation for final users, with its front-end automatically adapting to the device (mobile, desktop/kiosk, or immersive XR).
Visitors can enjoy e-Archeo 3D also collectively, in the Mengarelli Room, in the Banditaccia necropolis in Cerveteri, on three large screen, with the support of a human guide (fig.5).

Figure 5: e-Archeo 3D, collective version of the Web App accessible on three large screens, in the Mengarelli Room in Cerveteri.

3.2 e-Archeo Voices

e_Archeo Voices (https://voci.e-archeo.it/en/podcast/) is the podcast dedicated to the historical-archaeological narration of the 8 archaeological areas. Each archaeological area is narrated in the first person through the voice of a real-life or fictional but historically plausible character, or through the voice of iconic objects that are omniscient witnesses of each century and the various urban changes that occurred at each site. The narrative insights are constructed from scientific data collected by the universities but are presented in a non-specialist language to reach a wide audience. The narratives are accompanied by soundscapes that evoke events, settings and atmospheres. They can be enjoyed at any time and in any place (in the car, at home, or during a

site visit); each site is narrated through several episodes, with a total average duration of about 30 to 40 minutes.

3.3 e-Archeo Tactile

e_Archeo Tactile is an accessible installation with TUI (Tangible User Interface) entitled 'The Tomb-House of the Etruscans', and was realised following fully the principles of Universal Design.
It is located in the Mengarelli Room located in the Banditaccia necropolis, in Cerveteri. e-Archeo Tattile aims to involve the visitor by inviting him/her to interact with some three-dimensionally and materially reproduced contexts lying on a table, which serve as a conduit for an on-screen audiovisual narration (fig.6). The themes proposed in the TUI concern the Campana Tomb and Monte Abatone necropolis in Cerveteri, with its various types of house-like tombs. For the first time, the Monte Abatone necropolis is presented to the public, albeit in virtual form. It is in fact not possible to visit it since the archaeological excavation, which is still in progress, is covered over every year for conservation reasons.

Figure 6: e-Archeo Tactile: Tangible interface and multimedia screen in the Mengarelli Room in Cerveteri

e_Archeo Tactile is the result of a collaboration of a wide team of expertes, including experts in accessibility, aiming at creating a museum installation accessible at physical and cognitive levels (Museo Tattile Statale Omero, Ed, 2006).
The 3D physical models represent the reconstruction of a portion of the Monte Abatone Necropolis and the detail of the Campana Tomb. A theme of reflection and experimentation concerned the relationship between the dimensions of the objects and the degree of simplification or detail to be conferred to ensure correct tactile perception.
The TUI layout, the dimensions, distances, Braille captions have been designed with great attention (fig.7), and in its final version it consists of three models: the external reconstruction of a group of six tombs from Monte Abatone on the right; in the centre, the individual Campana Tomb

sectioned to show the planimetric distribution of its rooms; on the left, an even larger sectioned portion of the Campana Tomb allows the fixed furnishings of some rooms to be recognized.

Figure 7: design of the TUI layout

The maquette has chromatic and tactile characterisations, to identify the main materials: tuff and soil. The audio-visual narration is visible on the screen and can be activated by the buttons to the right of the maquettes. The contents are available with audio and subtitles in Italian and English, as well as in Italian (LIS) and International Sign Language (IS). The audio diffusion is via directional speakers to not create sound pollution in the environment, and the magnetic induction amplifier with Bluetooth helps users with hearing devices. Concerning the language of the audio-visual content, the main issues regarded, on the one hand, the simplification of the technical language in the LIS and IS translation, and on the other hand, the inclusion of spatial information to orientate the blind and create universally experienced narratives. Finally, all content is also made accessible by Braille texts and typhlodidactic aids, as tactile drawing (fig. 8).
A QR-code placed on the interactive table allows the user to reach the audio/video content also through the personal device, for closer viewing.

Figure 8: blind people testing e-Archeo Tactile in Sala Mengarelli

3.4 e-Archeo Human Interface

The e-Archeo HI® application was developed for the archaeological contexts of Cerveteri and Sirmione, starting from scientific data collected by the universities and proposed in a non-specialist narrative language. The installation is on public display at the Archaeological Museum of Sirmione and the Cerite National Archaeological Museum in Cerveteri. A character, represented by an actor acting in a costume, on a 1.1 scale, dialogues with the user interactively and narrates the archaeological area and its history. He also illustrates some of the museum's exhibits from the archaeological context.

For Sirmione the narrating character is the poet Catullus, who links his name to the site although he never lived in the villa we see today; for Cerveteri the character is Vel, owner of an important ceramics workshop in the town.The user interacts with the narrating character having the impression of conversing with him, vocally or by selecting topics via tablet, thanks to a narrative node structure.

e-Archeo HI® is placed near the showcases containing artefacts of great interest for the narrative (for instance in Cerveteri Museum, the Crater and the Kylix of Euphronius); the lights are dynamically switched on and off on the artefacts, synchronising with the narrative led by the virtual character. The digital installation thus functions as a ‘narrative hub’ or an ‘extended reality’ experience, because it has not an autonomous life, independent from the museum collections, but, instead, it dialogues with the physical objects, which react by lighting up as they are mentioned in the narrative (fig.9). The overall experience lasts about 20 minutes.

Figure 9: e-Archeo Human interface in Cerveteri Museum

3.5 e-Archeo Video

e-Archeo Video recounts the objectives of the e-Archeo project, the elements of innovation and good practice, the synergies among the different institutions, academies and creative industries, the methodologies and the outputs realised. It does so through real footage of the sites complemented by virtual reconstructions, often in camera tracking, interviews with the protagonists, backstage footage in the various workshops and examples of the project outputs (https://e-archeo.it/progetto/#introduzione).

The e-Archeo video also includes the 8 documentaries made by Rai Cultura presenting the archaeological sites, each about 8 minutes long.

CONCLUSIONS

The e-Archeo project aims to use digital technologies for the enhancement and promotion of the knowledge of the Italian archaeological heritage through eight pilot sites distributed across the national territory. Sustainability and accessibility were the common thread running through the project (ISO 9241-20), (EN 301549 Accessibility Requirements for ICT Products and Services), (Càndito and Meloni, 2022) (Cetorelli and Papi, 2024) and they were carried out in multiple forms: technological, managerial, socio-cultural, geographical, psycho-sensorial, cognitive, scientific, making the project a virtuous example of inclusive intervention on the Italian cultural heritage (Pietroni and Menconero, 2023).

(Figure 10: The various levels of accessibility of the e-Archeo project (graphic scheme by Sofia Menconero).

Multimedia and technological solutions are sustainable over time, easy to manage, robust and resistant to obsolescence. From the very beginning, the national superintendencies and museums have highlighted the need to deal with easy-to-manage technologies on a daily basis.
To guarantee socio-cultural accessibility, the project outputs were diversified, so that the multichannel approach could meet the needs of different audiences in terms of technological and archaeological literacy.
The diversification of online/onsite applications can also be considered a kind of geographic accessibility, as it allows those people who cannot physically travel to archaeological sites to consult the content available online.
The multichannel nature and variety of multimedia proposals, the tactile interfaces, and the adoption of Universal Design principles favour psycho-sensorial accessibility, allowing both collective and solitary experiences and including persons with sensory-motor disabilities.
A further form of cultural accessibility is the integration of the scientific back end that supported the virtual reconstructions. One of the cornerstones of the project was the adoption of FAIR and Open Science principles. Not only the results, but all the study phases were made open and published on Zenodo (Bucciero and Demetrescu, 2022), a European platform for long-term

preservation of data and metadata, with an open licence allowing their reuse (ShareAlike). This virtuous process has seen both academia and the creative industries converge.

The managers of some archaeological sites were thus able to launch a series of educational programmes and initiatives based on the results of the project. The latter were also used to increase the cultural offer to visitors, by developing new applications from the delivered data, such as the adaptation of 3D contents to be visualized through immersive virtual reality technologies (head mounted display) during the real visit.
Finally, a significant point of the project was the exchange of skills and the synergy that was created among the different actors involved, both from the public world, in particular research institutions, and from the private world, with companies developing innovative products through the application of shared methodologies to archaeology and virtual reconstructions.

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