AR and Knowledge Dissemination: the Case of the Museo Egizio

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Abstract

In the context of the growing pivotal role of digitalization for cultural institutions, the digital transition of the Museo Egizio di Torino is centered on the integration of heterogeneous information and data to implement the management, dissemination, and promotion of the Museum's collection. This digital transition is intended not only as a mere acquisition of technological tools but rather as the construction of an integrated system that facilitates dialogue and connections between all museum activities, from daily management to research, from the design of installations to the generation of multiple possible narratives. Within this framework, the essay illustrates, through two empirical case studies, the opportunities of AR technologies to implement the knowledge and dissemination of tangible and intangible aspects of the millennial historical objects preserved in the Museum.

Keywords
museum, digital transition, immersive environment, augmented reality (AR), data visualization.

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Introduction: Digital Transition and Cultural Institutions

Digital Culture is progressively spreading to all fields of knowledge and activities. In the field of archaeology, and specifically in the case of museums, it is deeply transforming cognitive approaches and working methods.

The digital transition is influencing large parts of society, including the cultural heritage field. Digital communication, the sharing of data and information, as well as research, are high on cultural institutions' agendas. Within this framework, the wide range of possible methods and tools may have three main potentials:

a) to increase and improve the efficiency of the daily activities;

b) to open new directions of research;

c) to implement new ways to disseminate knowledge and information.

Digital elements are currently present in nearly all aspects of the organization and management of any cultural institution, including museums. Considering how the number and importance of digitalized information and data will keep increasing in the coming years a defined strategy is strongly needed. If all strategies are somehow at least in part interrelated, the Digital Strategy is a truly transversal field of action, that encompasses questions, answers, and decisions that are shared among different museum departments.Analyzing the current state of the art of digital services aiming to innovate the way institutions interact with visitors, it is easy to find discrepancies.

In Europe, there are some interesting experiments such as the Futurium Museum (Berlin), which, facilitated by the extremely innovation-driven nature of its content, has managed to achieve a perfectly integrated experience between online and offline through systems of in-depth analysis after the physical visit.

In Italy, the situation is quite different. Although 70% of museums have at least one technological tool to support the onsite visit (32% have a touch screen, 33% use QR code and e-beacon and 32% adopt audioguide) [Osservatorio Innovazione Digitale nei Beni e Attività Culturali 2021] only 24% of them have drawn up a strategic digital innovation plan, rethinking their digital strategies to meet a true innovation [Lampoonmagazine.com 2021].

Additionally, the interactions between institutions and their audiences remained almost unchanged compared to previous years. Only 5% of Italian institutions offer interactive activities and games to engage with potential visitors [Lampoonmagazine.com 2021].

Within this framework, in response to the digital challenges, museums and galleries have to grapple with organizations and their staff need to adjust to the new ways of thinking and working in a digital-physical world.

A Digital Strategy only in part depends on technical aspects. Technology is a tool, that must be mastered to convey precise messages, and these, in turn, must be established in advance based on a shared vision among the stakeholders and the overall cultural and legal policy of the country. Finally, the implementation of a digital strategy requests a specific financial commitment, that must be substantial but, most of all, constant over time, as the rapid technological evolution requests constant updates. Within a museum's Digital Strategy visual communication play a key role. Museums aim at preserving cultural identity and collective memory as well as interpreting and communicating their meanings to wide and heterogeneous audiences. By their nature, they are open and dynamic places that encourage, promote, and host the interaction between objects, researchers, and audiences. In this framework, digital advances in AR technology enable the creation of immersive interaction environments. This opens up great opportunities for data visualization supporting the understanding and interpretation processes of cultural objects.

The opportunities of Augmented Reality (AR) technologies can offer a wide range of solutions applicable to several contexts, objects, narratives, and audience targets, and with different access modes (i.e. individual or collective visualization, various immersive levels, etc.,). Within this framework, the following paragraphs present the concept, the design, and the outcomes of two AR applications tested by the Museo Egizio di Torino.

The Museo Egizio di Torino, an archaeological museum and research center focused on socio-cultural topics [1], tested through two empirical applications the recent developments of AR and its potential for recognition, communication, and interaction with physical space. The two projects are heterogenous for narrative strategies, topic, communication goals and representation modalities testing different uses of AR techniques. Both projects have been selected to show the opportunities of AR to disseminate and communicate the research outputs of the analysis and studies carried out by the Museum.
The first one named *Stone. Pietre Egizie* has been developed by a team made up of geologists, architects, Egyptologists, archaeologists and computer scientists, which developed a new tool

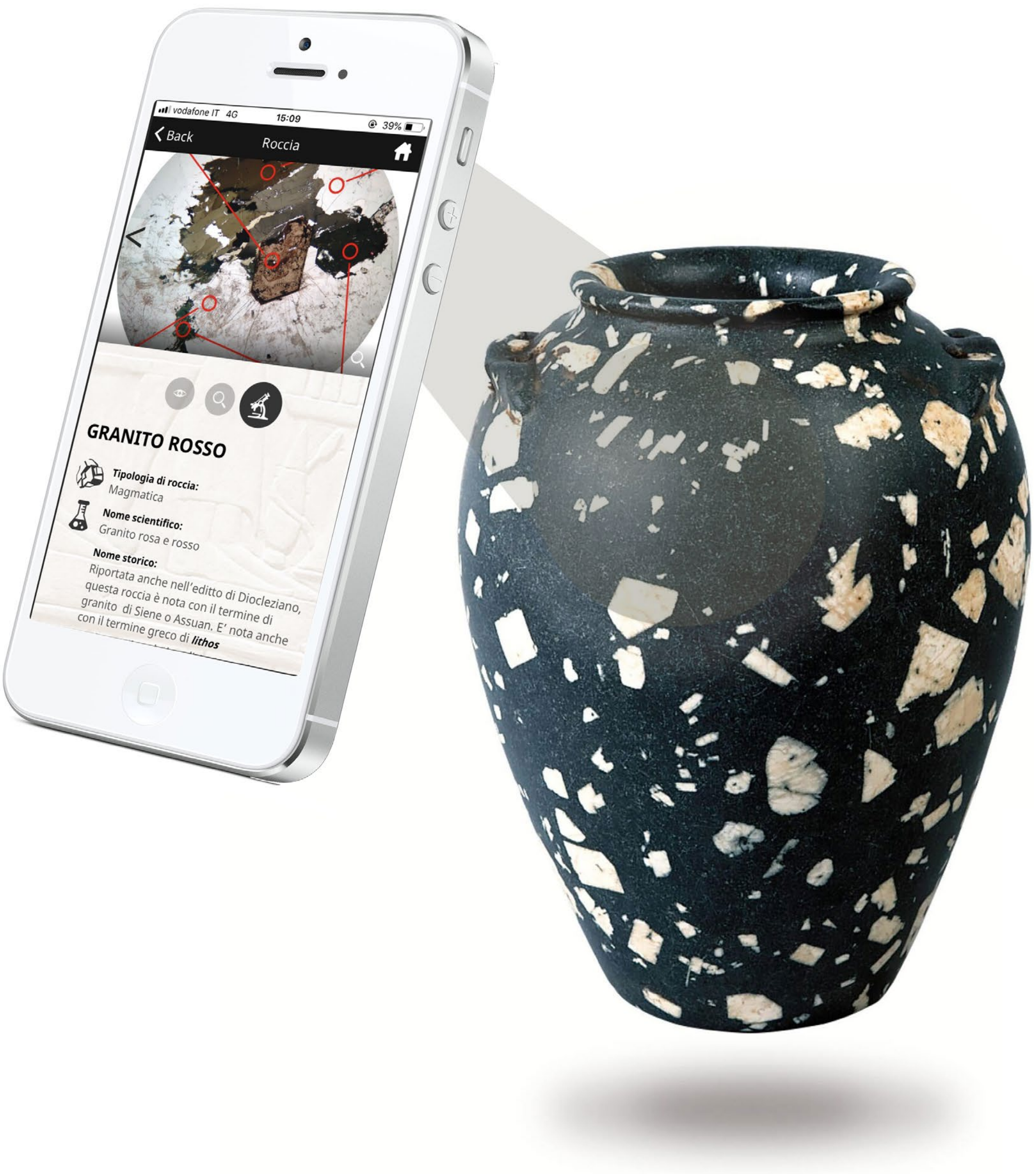

Fig. 1. Operation mode of the app "Stone. Pietre Egizie". Image elaboration: Author.

available to the public to understand and know the type and properties of the rocks of the collection's statues, sculptures and objects as well as those employed for the museum's building [2]. The app allows visitors to observe granite, porphyry, limestone and sandstone, discovering their nature, composition, origin and the reasons why they were chosen by the Ancient Egyptians (Fig. 1). The app is organized based on the historical and artistic importance of the collection objects, but also and above all on the type of rock used [3].
More specifically, fifty objects were chosen. The selected objects located in eleven different rooms within the Museum were identified according to historical relevance and type of stone material.
Further, the *Papyrus of the mines* was also included in the objects' list. The papyrus is the oldest geological map ever made, which boasts over 3000 years of history, dating back to the reign of Ramesses IV.
The app is structured into nine sections (Fig. 2). These include: 1) "Start" to begin the exploration and discovery of the objects made of stone; 2) "Introduction" defining methodology and goals of the app; 3) "Stones" reporting a list of the different types of stone that can be found in the Museum objects. This section provides a short info-graphic description of each stone including information on: stone type, scientific name, historical name, macroscopic description, main uses and quarries location in the Ancient Egypt; 4) "Artifacts" presenting the images of the selected objects and the stone they are made of. For each artifact there is a biography reporting information on epoch, acquisition period, place of discovery, dimensions and short description; 5) "Quarries of Egypt" locating and describing the quarries in ancient Egypt and in the Ptolemaic-Roman period; 6) "Geology" describing and explaining how

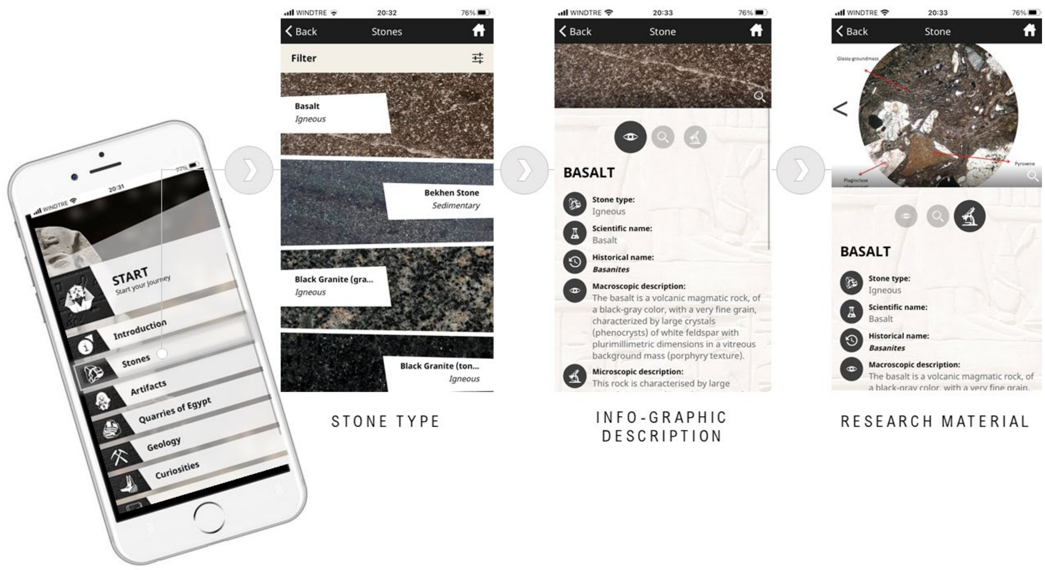

Fig. 2. Example of the section «Stone» focusing on the Basalt stone. This section provides a short info–graphic description of the basalt stone including information on the stone type, scientific name, historical name, macroscopic description, main uses and quarries location in Ancient Egypt. Image elaboration: Author.

the richly composite geology of the country made possible the wide variety of ornamental stones in Egypt; 7) "Curiosities" offering contents and providing the tools to investigate the rocks, as well as the possibility of observing the digitized objects, such as the statue of the goddess Sekhmet, at 360 degrees; 8) "Glossary" describing all the technical terms used; 9) "Credits" reporting the people involved in the project development.
According to the app structure, it is possible to choose several exploration paths, focusing on the masterpieces, following the chronological order, observing the types of rock at a macro and microscopic level, learning about the quarries from which the materials were extracted (supported by a glossary).
The section of the app dedicated to 'curiosities' offers contents and provides the tools to investigate the rocks, as well as the possibility of observing the digitized objects, such as the statue of the goddess Sekhmet, at 360 degrees.

Through the app, the designed AR content can be accessed by mapping existing elements including vases, statues, amulets, jars, sarcophagus, steles, etc.
The second case study consisted of the projection mapping of the Butehamon coffin [4]. Within the framework of the temporary exhibition *Archeologia Invisibile* [5], a section of the temporary exhibit was dedicated to showing the set of techniques used to study materials, production methods and the conservation history of finds – making it possible to question objects.
In the achievement of this goal, the workflow for the projection mapping on the copy of the Butehamon coffin included several steps.
The 3D digital documentation of the original Butehamon coffin has been the fundamental basis to generate a physical replica from a high-resolution 3D model of the external, anthropoid coffin of the scribe Butehamon. The survey included range-based and image-based techniques. The survey with a triangulation scanner, was useful to record all the small decorations of the surface, while photogrammetry allowed to obtain a complete 3D model and a high-quality and sub-millimetric texture of the recorded coffin [Mandelli et al. 2019].
From the 3D model of the coffin, it has been possible to generate a 3D printed copy, with millimetric accuracy, on a 1:1 scale. The generated replica acted as a support for a projection mapping installation meant to re-project a pattern of images onto the coffin's surface, including the results of different radiometric and colorimetric analyses [6] performed in the recent past by Museo Egizio and Musei Vaticani (Fig. 3). The 3D printed copy was meant to

Fig. 3. Example of the metric, radiometric and colorimetric analyses carried out on the Butehamon coffin. Image elaboration: Author.

have a projection-mapped on the lid part to show the audience details of the construction and the pictorial decoration process. Additionally, two side videos were used to represent the history, the craftsmanship, and the scientific analyses conducted on *Butehamon's coffin*. At the base of the projection mapping setup, there are the same data generated by the Laser scan process: an 8 million polygon 3D model for the lid of the coffin, obtained from the dense point cloud.
To make the animation process lighter and lower render times, a mixed retopology technique was used either by hand in the 3D software Maya and using Sketch Retopo. This allowed the final model to be more detailed in the face and crack zones. Retopology also allowed the geometry to follow the natural curves of the surface, thus making the UV Unwrapping of the texture easier and more consistent. The final model used for the animated content is made out of approximately 500.0000 polygons. All the details of the high-resolution 3D model were not discarded, but converted into a normal map texture through the normals baking process and then re-applied to the low-resolution model. Normal map textures keep the information on the reflection direction of the light (thus the geometry orientation) in specific zones where the texture is applied following the same UVW coordinates as the RGB color information, resulting in a sharper, more detailed model with a lower number of polygons. The same normal map was also used to obtain the X-ray version of the coffin. The X-ray photo of the lid was deformed using the visible light information stored in the RGB UVW texture and warped using the texture mapping internal tool in the Maya software. The same process was applied to the case of the coffin. For the video ani-

mation, the software Adobe After Effects and the plugin Element 3D were used. In After Effects the 3D OBJ, a low-resolution model was imported and scaled using a meter to pixels conversion. After a site inspection on-location, the position of the virtual top camera was estimated by measuring the projector-to-3D print distance and by converting the 1,19:1 projector throw ratio to an equivalent focal length.
The 3D model of the coffin and the projector were oriented horizontally to maximize the pixel used for actual color information. As the final installation consists of an animation mapped on the 3D printed replica of the coffin and two projections on the sides illustrating the stratigraphy and pictorial techniques, it was decided that all the three contents needed to be in-sync. Two additional cameras, a master and a slave camera, were created. They were meant to have a free movement, to be rotating around and getting closer to the coffin, to show the whole surface and close-ups of fine details of the coffin. The slave camera is parented to the master one and mirrors its movement along the Z (depth) axis. Following the main soundtrack of the installation the whole camera movements were animated and the captions for all the moments of the videos aligned in the timeline for the Master and the slave cameras (Fig. 4). Completed the whole animation, the two camera views (master and slave) were rendered and three 1920x1080 pixels, h.264, .mp4, 15.0000 kbps CBR files were generated to be used in three in-sync BrightSign players inside the installation. Once the 3D-printed coffin was in position, the projection mapping process began. The projector placed on top of the coffin was connected via HDMI to a MacBook Pro Laptop. The animation video of the top view was loaded in the

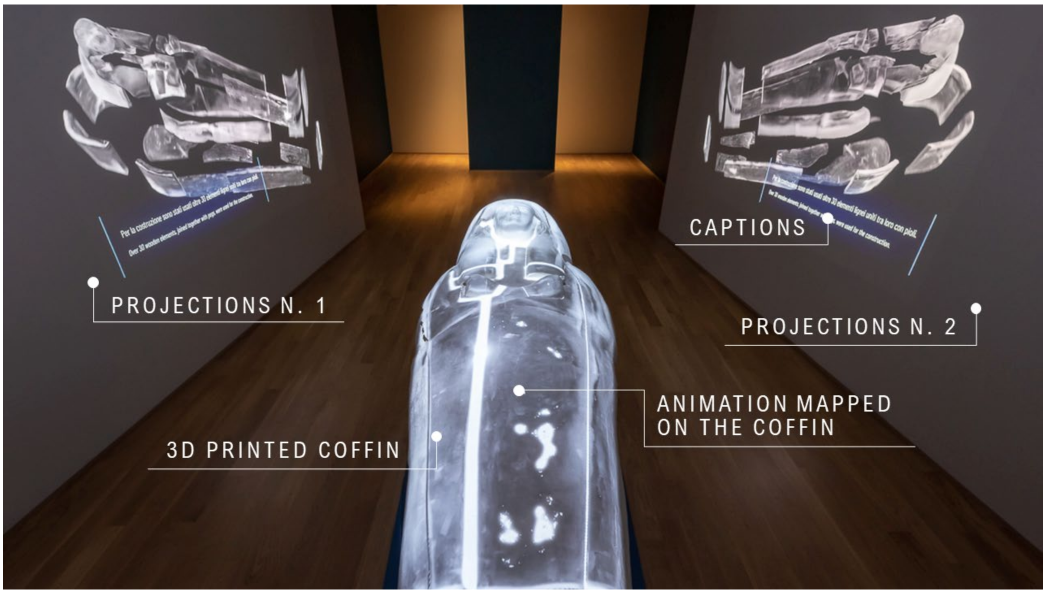

Fig. 4. Main elements of the projection mapping process on the 3D printed replica of the Butehamon coffin. Image elaboration: Author.

mapping software Millumin. This software allows users to apply a warping grid to a 2D video to align it with a 3D surface and to play it in real-time. The deformed video was then rendered, converted in the same format as the other two, and synced in the BrightSign player of the top projector. This installation required the collaboration of different experts in digital documentation, visual communication, visual design, 3D modeling, 3D animation.
This case study illustrates principles, tools, and results of the meticulous work of recomposing information, data and notions made possible today by digital documentation and representation technologies and tools. The final result encouraged a thorough discussion on the interaction of digital representation in the study and dissemination of archaeological objects.
The two projects are representative of the opportunities of AR techniques and tools in terms of communication and visualization of concepts, information and data. Both applications present two different access modes. The app "Stone. Pietre Egizie" has been designed for individual access to discover and know the materiality of the Museum's collection. In the case of the Butehamon coffin, the projection mapping has been employed for a collective and synchronous visualization representing the analysis carried out on this layered object with a millennial history.

Future Perspectives: the Opportunities of AR Applications

Future perspectives foresee the development of Augmented Urban Art (AUA) initiatives with the final aim of bringing the Museum out of the Museum's building. The idea consists in employing AR techniques to visualize from outdoor public spaces (i.e. the streets and the square that delimit the Museum) part of the indoor spaces of the Museo Egizio. This kind of application would have a double goal.

On one side, it acts as a teasing reveal strategy [7] to promote Museum exploration.

On the other side, Augmented Urban Art initiatives open up the Museum to the city, enabling visitors to grasp the urban history of Torino, and become aware of its cultural offer. The extension of this kind of initiative to other cultural institutions, at the city level, would be desirable to increase the potential audience and amplify the expected results. More specifically, the combination of digital representation with real built environments could: 1) increase the awareness and /or curiosity toward the Museum building and its collection; 2) promote the exploration of the museum; 3) test the potential of visual communication to disclose the content of historic building; 4) strength the relationship between the Museum and its urban context.

Another potential application of AR is related to the daily facility management and the museum's temporary exhibitions. Several studies have shown how digital models and associated information, schedules and databases can be shared through digital twins, favoring information sharing and minimizing data loss. Thanks to the development of AR platforms, it is possible to achieve an immersive form of human-model interaction [Banfi 2021].

Conclusions

The proposed examples underline the potential of digital representation for the dissemination of humanistic and technical knowledge in synchronous mode. The two presented projects required a transdisciplinary approach in which the representation played a crucial role. Digital representations combined with AR techniques allowed to communicate the complexity of transformations and historical layering that feature cultural heritage objects. The digital twins generated have been integrated with the real environment through interfaces and algorithms based upon data collected and processed through optical-perspective devices. Both empirical experiences share a common approach which is aimed at:

- Considering the real objects not just as the target for the activation of AR animations but as a base to georeference and localize the representation of invisible aspects and technical information that could not be displayed together by analogical means.
- Exploring the potential of AR visualization opportunities, paying constant attention to the relationship between real space and digital information.
- Testing different ways to share and disseminate information associated with the invisible features of the Museum's collection disclosing new meanings and stories embedded into cultural heritage objects.

The proposed examples evidence how representation solutions based on AR technology can provide the chance to re-design the relationship between material and immaterial culture, providing a more flexible interplay of the onsite/online public engagement by harmonizing the digital and material experience of cultural heritage as complementary phases of the same dissemination process.

Notes

[1] According to the ICOM definition of Museum, the museum has also to be intended as a research institution. Indeed, ICOM Statutes, adopted by the 22nd General Assembly in Vienna, Austria, on 24 August 2007, define a museum as follows: "A museum is a non–profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment".

[2] The project stems from the collaboration between the Department of Earth Sciences of the University of Turin and the Museo Egizio Museum of Turin. The project goals aim at broadening and deepening the knowledge of the museum collection by proposing different interpretations tools. The app development included an interdisciplinary team coordinated by Professor Alessandro Borghi of the Department of Earth Sciences of the University of Turin. From the economic side, the project was developed thanks to the financial contribution of the CRT Foundation, in the context of *Research and Education* projects.

[3] In Egypt, ornamental rocks represent a huge tangible element of material, historical and cultural richness. This ancient civilization has been able to make the most of what nature has offered them. The Egyptians chose among the various types of rocks in their territory those with the best characteristics both from an aesthetic and mechanical point of view.

[4] The Butehamon coffin dates back to 1076–944 BCE. It is made of wood and it is fully painted. The dimensions of the lid are 211 x 75 x 42 cm, while the box measures 210 x 74 x 43 cm. The coffin is part of a set of coffins, probably found in the tomb of Nakhtmin (Theban Tomb 291) in Deir el–Medina, owning the Third Intermediate Period. Currently, the coffins of Butehamon are on display in the Galleria dei Sarcofagi at Museo Egizio, Turin (AA. VV., 2015), [Ciccopiedi 2019].

[5] *Archeologia Invisibile* is the title of the temporary exhibition that opened on March 13th, 2019. The purpose of the exhibition is to illustrate the principles, tools, examples and results of the meticulous work of recomposition of information, data and knowledge made possible today by the application of science to other disciplines and, in particular, to the study of the findings.

[6] Museo Egizio and Musei Vaticani carried out a non–invasive diagnostic campaign disclosing several aspects of the object's history and on the carpentry techniques which were used. More specifically, the x–rays analysis revealed the general structure of the lid and the box. Moreover, the x–rays showed several interventions to re–shape the reused elements, both in the area of the hands and of the face. [Mandelli et al. 2019].

[7] The term 'teasing reveal strategy' refers to a campaign that is set up in two stages, first to encourage questioning and then to provide an answer in the form of revelation. The teasing phase exposes a subject, evokes questioning and creates interest to maximize the sharing of a promotion campaign. The second phase constitutes a revelation and brings an answer to the questioning phase, in this case, an actual visit to the Museum.

References

AA. VV. (2015). *Museo Egizio*. Torino: Franco Cosimo Panini.

Banfi Fabrizio (2021). The Evolution of Interactivity, Immersion and Interoperability in HBIM: Digital Model Uses, VR and AR for Built Cultural Heritage. In *ISPRS International Journal of Geo-Information*, 10 (10), 2021, 685.

Ciccopiedi Caterina (a cura di) (2019). *Archeologia invisibile*. Torino: Franco Cosimo Panini.

Giannini Tula, Bowen Jonathan (2018). Of Museums and Digital Culture: A landscape view. In *Electronic Visualisation and the Arts (EVA)*, pp. 172-179.

Greco Christian, Rossi Corinna, Della Torre Stefano (2020). Digitalization and Cultural Heritage between Crisis and Opportunities: the Experience of the Egyptian Museum in Turin. In *Il Capitale Culturale: Studies on the Value of Cultural Heritage*, Supplementi,11, 2020, pp. 197-212.

Lampoonmagazine.com (2021). Digital disruption in Milan contemporary art scene: Bubbles at the Hangar Bicocca.
https://lampoonmagazine.com/article/2021/05/24/bubbles-hangar-bicocca/#:~:text=.%20Only%205%25%20of,and%20applying%20them (01 January 2022).

Lo Turco Massimiliano, Spallone Roberta (2019). Piattaforme digitali integrate per i Beni Culturali. Alcune esperienze della Scuola di Architettura del Politecnico di Torino. In *Paesaggio Urbano*, 1, 2019, pp. 52-65.

Mandelli Alessandro, Perfetti, Luca, Fiorillo Fausta, Fassi, Francesco, Rossi Corinna Greco Christian. (2019). The digitalization of ancient Egyptian coffins: a discussion over different techniques for recording fine details. In *ISPRS – International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W15, 2019, pp. 743-750.

Mezzino Davide, Lori Francesca Valentina Luisa (2021). The Digital Transformation of the Museo Egizio. In *Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES*, pp. 1-7.

Museo Egizio (2020). Outer coffin of Butehamon.
https://collezioni.museoegizio.it/en-GB/material/Cat_2236 (03 December 2021).

Osservatorio Innovazione Digitale nei Beni e Attività Culturali (2021). Report Extended Experience: la sfida per l'ecosistema culturale. Maggio 2021.
https://www.osservatori.net/it/prodotti/formato/report/innovazione-digitale-musei-italiani-2021-report (03 February 2022).

Spallone Roberta, Palma Valerio (2021). AR&AI in the Didactics of the Representation Disciplines. In Giordano Andrea, Russo Michele, Spallone Roberta (eds.). *Representation Challenges. Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain*. Milano: FrancoAngeli, pp. 421-425.

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