proceedings

ISSN 2504-3900

Una Quantum 2022: Open Source Technologies for Cultural Heritage, Cultural Activities and Tourism

Rome, Italy | 15–16 December 2022
sites.google.com/unaquantum.com/uq2022/home

Volume 96 · UQ 2022

MDPI

proceedings

MDPI

Proceeding Paper

Archaeobotany and Bioanthropology: The Potential of VR and 3D Printing in the Enhancement of Archaeological Organic Remains †

Roberta Manzollino [1,2,*], Giulia Chellini [2], Paola La Torre [2,3], Saverio Giulio Malatesta [2], Marco Raoul Marini [4] and Claudia Moricca [5]

1. Department of Classics, Sapienza University of Rome, 00185 Rome, Italy
2. Interdepartmental Center of Research DigiLab, Sapienza University of Rome, 00185 Rome, Italy; paola.latorre@uniroma1.it (P.L.T.); saveriogiulio.malatesta@uniroma1.it (S.G.M.); giulia.chellini@uniroma1.it (G.C.)
3. Department of History, Culture, Religions and History of Art and Entertainment, Sapienza University of Rome, 00185 Rome, Italy
4. Computer Science Department, Sapienza University of Rome, 00185 Rome, Italy; marini@di.uniroma1.it
5. Department of Environmental Biology, Sapienza University of Rome, 00185 Rome, Italy; claudia.moricca@uniroma1.it

* Correspondence: roberta.manzollino@uniroma1.it

† Presented at the Una Quantum 2022: Open Source Technologies for Cultural Heritage, Cultural Activities and Tourism, Rome, Italy, 15–16 December 2022.

Abstract: The term bioarchaeology refers to the study of archaeological remains of organic origin, including human and botanical remains, which are highly informative for reconstructing past human–environment relationships. However, they are not very tangible, either because of ethical issues or their reduced size. Using novel technologies, such as modeling, 3D printing, and virtual reality, these remains have been made accessible, manipulable, and inclusive. The objective of this work is the technological enhancement of bioarchaeological remains through the development of an innovative, non-destructive, non-invasive, and reproducible protocol. In this way, more effective dissemination of the information obtained from studying these materials is possible, making them more accessible to different audiences.

Keywords: archaeobotany; pollen; palynology; virtual reality; virtual anthropology; education; accessibility; 3D modeling; 3D printing

Citation: Manzollino, R.; Chellini, G.; La Torre, P.; Malatesta, S.G.; Marini, M.R.; Moricca, C. Archaeobotany and Bioanthropology: The Potential of VR and 3D Printing in the Enhancement of Archaeological Organic Remains. *Proceedings* **2024**, *96*, 15. https://doi.org/10.3390/proceedings2024096015

Academic Editors: Gabriele Ciccone and Giuseppe Guarino

Published: 27 March 2024

1. Introduction

Human skeletal remains found during archaeological excavations are an important source of direct knowledge for the reconstruction of life conditions in the past. The information resulting from their study can help archaeologists reconstruct the investigated period of human history [1]. To obtain this kind of information, it is fundamental to have appropriate expertise about the human skeleton, its anatomy, properties, and functions. There are many disciplines that focus on the human skeleton, such as osteology, skeletal biology, and biological anthropology (bioanthropology). The fundamental subject matter of bioanthropology is an interest in, and an exploration of, human origins and human variation [2]. However, non-experts are often unfamiliar with the professional figure of the bioanthropologist, and how the study of skeletons can help the archaeological investigation. An anthropological study often requires handling bones: the rotation and visualization from all perspectives can help better understand the biological morphology of bones. Clearly, non-specialists cannot handle human remains, but they can observe them in archaeological museums. Museums that exhibit human remains, such as ancient skeletons or mummies, provide a non-interactive experience to visitors. Usually, they can only observe them through glass and are not allowed to touch or manipulate them due to conservation and ethical reasons [3].

While human remains are traditionally the focus of bioarchaeology, this field also encompasses other disciplines, covering the study of all biological remains (fauna and flora) recovered during archaeological excavations [4]. This includes archaeobotany, the study of plant remains recovered from contexts affected by human presence, i.e., archaeological sites [5]. Archaeobotany is fundamental for reconstruction of the role that humans played in shaping the past environment and includes both the study of macroscopical (such as seeds, fruits, and wood) and microscopical plant parts (e.g., pollen and non-pollen palynomorphs—NPPs).

Concerning pollen grains, they are the male gametophytes of seed plants [6]. They are characterized by different morphologies and ultrastructural features [7], which make it possible to recognize different families and genera, and more rarely, also species [5]. The study of pollen is called palynology and can be used to investigate cultural landscapes of both paleoenvironmental and archaeological records [8]. The comparison of past and present pollen grains makes it possible to evaluate environmental transformations, which occurred due to both natural and anthropogenic factors. The latter are recorded, for example, by the spread of cereals (Cerealia-type), the increase in wild synanthropic taxa, and the presence of cultivated plants [9].

From a practical point of view, palynological analysis is less straightforward than the study of seeds and fruits, which can be seen by the naked eye (or through a stereomicroscope) and are more tangible. Pollen extraction requires a long chemical treatment, which involves the use of strong acids and bases (e.g., [10]). After extraction, pollen is preserved in glycerin, mounted on slides, and studied under a transmitted light microscope. Although pollen grains are tridimensional, the observed images appear "flat". Their morphology can be better observed by adjusting the focus and by tapping the coverslip with a preparation needle [11]. For all these reasons, understanding pollen morphology can be complicated for both students approaching palynology and for the general public. The former category might not be able to understand the differences between different types of apertures and ornamentations. The latter might have trouble understanding how something apparently "invisible" carries so much information.

New technologies are a great help to face the issues related to the intangibility of bioarchaeological heritage, overcoming both ethical (bones) and size (pollen) issues.

Indeed, digital technologies have made it possible to interact with osteological remains in a virtual environment. This has enabled the origin of Virtual Anthropology (VA) through the combined use of computer science and bioanthropology for the study, conservation, enhancement, and communication of human remains [12]. The virtual acquisition of human remains makes anthropological analysis free of any risk of damage to the original specimen. Moreover, digitalization leads to significant advantages in educational, dissemination, and enhancement aspects [13], especially due to the exploitation of Virtual and Augmented Reality (respectively, VR and AR) devices in contexts such as culture dissemination, gaming, and simulations [13]. Human–computer interaction and information technologies play a key role when the main goal is knowledge transfer [14,15], and cultural heritage has taken advantage of their usage [16].

The use of digital techniques has made it possible to observe and study various cultural objects such as statues, vases, and coins [17,18] deeper than in the classic observation, and has also found an application in bioarchaeological evidence in the form of seeds, fruits, bones, and mummies [19,20]. In addition, immersive VR devices, such as those based on the Head-Mounted Display (HMD), provide the opportunity to interact with these artifacts not only by manipulating, rotating, and moving them but also by immersively exploring their insides. Moreover, these technologies have helped overcome accessibility issues [21], thereby facilitating physical and logical tasks.

In this perspective, further help comes from three-dimensional (3D) printing, which represents an important possibility for accessibility to knowledge for categories of users with specific needs: for people with visual or learning impairments, touching a three-dimensional model surely represents a possibility of interaction, which can favor a better understanding of the object. For this reason, our project has a strong educational value and represents a communicative possibility of the results of scientific studies for audiences with different specificities, both non-experts and experts, in compliance with all the needs of use and valorization.

2. Materials and Methods

In this work, we present the application of VR and 3D printing on two different typologies of bioarchaeological heritage: pollen grains and human remains.

2.1. Pollen Grains

Pollen grains with different morphologies of taxa commonly found in archaeological sites and typically associated with human presence were selected for this study. These are represented by *Triticum aestivum* L. (bread wheat; psilate and ulcerate) [22], *Corylus avellana* L. (hazelnut; psilate and triporate) [23], and *Bellis perennis* L. (daisy; tricolporate and echinate) [24]. Considering pollen identification cannot always be performed at a species level, in archaeological sediments, the chosen taxa would be identified as *Triticum*, *Corylus*, and Asteraceae Asteroideae.

Three-dimensional models of pollen grains were made using Blender 4.0, a versatile open-source software which allows the management of each stage of the creation of 3D content [25]. Scanning electron microscopy (SEM) images, illustrating diagnostic characteristics of three pollen taxa, were chosen from the PalDat database [26]. These were then loaded into Blender as references.

The definition of the polygonal volumes through mesh primitives represented the starting point of the 3D modeling workflow; spheres were used in all the selected cases.

In the case of *Triticum aestivum* [22] and *Corylus avellana* [23] pollen grains, an increase in the polygonal density of the geometries was opted for using the Subdivision surface modifier, reaching a high number of polygons and the resolution necessary to operate within the sculpting workspace. In this phase, the volumetric dimensions of each model were corrected using the Grab brush, according to the front, back, and side views of the reference images. A combination of the Inflate brush and the Draw brush, in addition and subtraction, was used to model the pores of the *Corylus avellana* pollen grain and the annulus of the *Triticum aestivum* grain. The increase in polygonal density was also useful for the application of a noise texture to the volumes through a Displace modifier, allowing the irregularities that characterize the outer surfaces to be obtained. To model the *Bellis annua* pollen grain [24], two subdivision levels were applied using the Subdivision surface modifier, which made it possible to obtain the required polygonal density. Echines were obtained by moving individual vertices along the normals. As in the previous cases, a noise texture was applied to the model using the Displace modifier to mimic the outer surface. The three colpori were obtained through subtraction Boolean operations.

The 3D models, decimated and optimized for 3D printing using Print Toolbox, a Blender add-on, were then exported in .ply format and imported into Ultimaker Cura, 5.6.0, an open-source slicing software. Models were printed using a PLA filament using a 3D AnyCubic i3 Mega S equipped with a maximum resolution of 50 microns, and an accuracy of 0.0125 mm on the X and Y axes, and 0.002 mm on the *Z* axis.

2.2. Bioanthropological Remains

We created an interactive and immersive VR-based experience to show the differences between the sexes (sexual dimorphism) in the human cranium and some basic principles of osteology. We used the Oculus Rift CV1, Leap Motion devices, and a high-end desktop computer with a CPU Intel i7 5930k, RAM 32GB DDR4 3200MHz, motherboard Asus Rampage V Extreme, a Samsung SSD storage 860 Pro 1TB, and Nvidia GeForce RTX 2080ti. Leap Motion's software can discern 27 distinct hand elements, including bones and joints, and track them even when they are obscured by other parts of the hand. With a 120 Hz refresh rate and low-latency software, the time between motion and photon falls below the human perception threshold.

Two phases can be distinguished within the experience, which takes place in a futuristic environment. The necessary instructions are provided to the user in the first phase, teaching them how to move around the virtual environment and interact with objects in the scene. The user then accesses the main scenario and begins to visually explore the virtual environment. In the front view, there is a desk with a monitor displaying the Sapienza University logo, a flashlight, a pen with a notebook, and three skulls. The narrator invites the user to pick up two skulls and explore any potential differences, while explaining the morphology of the male and female cranium. The user is then invited to use an osteometric table, available in the scene, to measure the skulls. An algorithmic approach coupled with statistical analyses described in the work authored by Manzollino et al. [27] were used to digitally generate the skulls in the virtual environment from references of male and female skulls.

In phase two, the user finds a series of commingled bones on the scene, which they are then asked to reassemble with the help of a reference skeleton. This task should be easily completed thanks to the skills acquired during phase one. The experience is completed when all the bones are placed in anatomical position, considering a generous margin of error (about 0.3 m from the correct place for each axis and 30 degrees for each rotation axis). However, if a user faces difficulties with the task, the operator can interrupt the experience with a slightly different ending. Unity3D has been utilized to develop the interactive environment and to make it a touchless exploration VR experience.

3. Results and Discussion

A range of models aiming at increasing the accessibility of bioarchaeology to the public, such as non-specialists and students, was developed using the aforementioned methods. The intended audience is not limited to any particular group and is open to people of all ages, even those who are not familiar with 3D-printed objects and VR devices, aiming at providing an enjoyable experience to everyone who engages with digital technologies.

Firstly, we obtained 3D models of pollen grains (Figure 1), giving a 360° view of each of them, thus highlighting their diagnostic characters. This contrasts with the two-dimensional view typically observed during routine analyses, and results in a more straightforward understanding of the object. This is not the first attempt of pollen digitalization. Worthy of mention is the recently published 3D Pollen Project [28], an open-access repository of 3D pollen scans and surface files obtained by confocal laser scanning of pollen reference collections and herbarium specimens.

3D printing (Figure 1) has allowed us to enlarge our pool of potential users by providing a tactile experience of the elements, otherwise usable only, for example, through sight. Humans perceive and communicate through all five senses. Sight is perhaps the most encouraged sense and that allows a greater possibility of use in all areas [29]. However, for those with a visual impairment, this implies being excluded from many communication possibilities; for example, it is impossible to see pollen under a microscope. Another sense involved in the perception of physical forms is touch. For people with visual impairments but also for people with cognitive disabilities, not being able to touch represents an enormous limit in the possibilities of knowing an object, and its shape and size.

The potential of this project in the educational and instructional field plays a key role in relation to recent pedagogical studies related to an alternative possibility of educational approach, so-called Object-Based Learning [30]. This approach is defined as active learning and is useful to stimulate critical thinking through direct interaction with physical objects, such as artworks, documents, or 3D-printed objects [31]. Hence, objects can be studied in an active and collaborative way. This could represent a possibility for inclusion in classrooms where there are students with specific needs. New models of accessible learning can thus be generated. One example concerns the possibility of having 3D models of archaeological, archaeobotanical, or anthropological artifacts in schools.

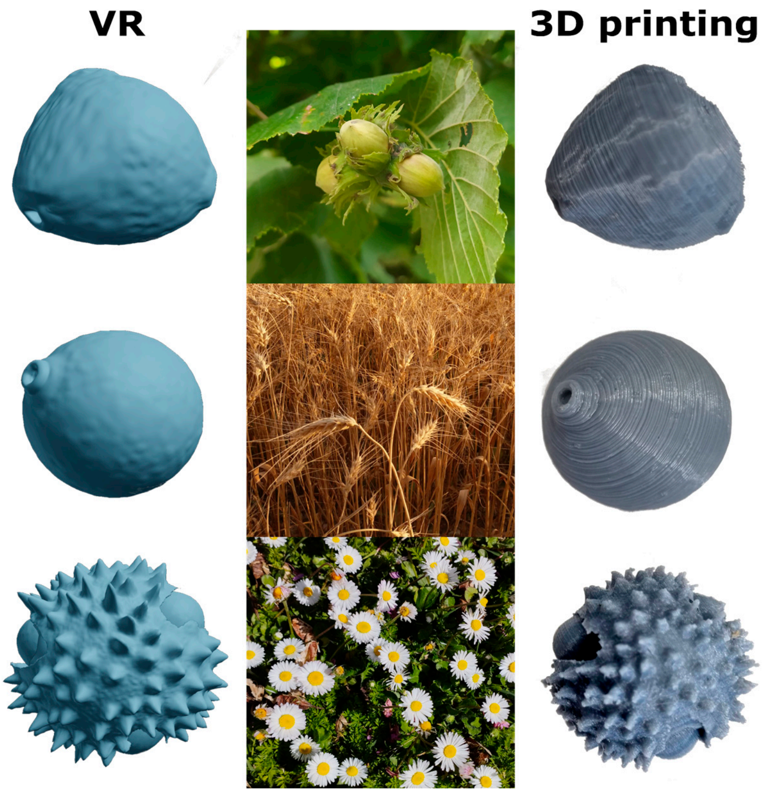


Figure 1. VR models of selected pollen grains (first column); photos of plants the pollen grains belong to (second column): *Corylus avellana*, *Triticum aestivum*, *Bellis perennis*; printed 3D models of selected pollen grains.

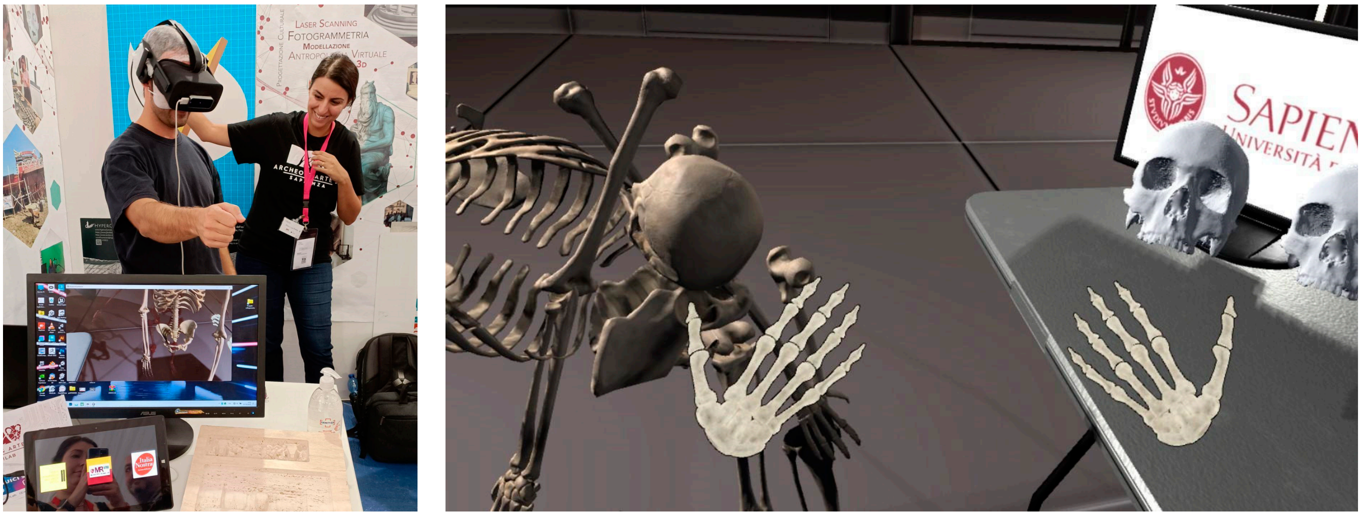
In this example, 3D printing represents a possibility of accessible communication; the use of 3D models is not exclusively dedicated to people with disabilities, but it can work for all students: it is not a specific adaptation but represents a new possible model of inclusive and participatory teaching [32].

The 3D models created can also be part of animated digital pathways or virtual environments, offering new possible educational and learning developments, such as the case study of VR with an anthropological theme (Figure 2). The educational–didactic element based on gaming allows greater involvement of participants who learn in a dynamic and participatory way, even with more complex concepts. The fruition and usability of an immersive VR system focused on skeletal anatomy have been studied previously [27] with the aim of providing guidelines for the communication and education of human osteology.

The 3D modeling, 3D printing, and VR applications proposed in this paper combine innovation, technology, and alternative educational solutions. The challenge of making bioarchaeology accessible and inclusive using digital technologies is a key aspect that has led to the creation of the digital models and 3D prints. In addition, the experiential and immersive nature of the virtual environment allows us to show the potential of these digital replicas for the enhancement and communication of bioorganic heritage.

As mentioned above, VA and VR can enrich the experience of learning about human osteology, even in museums.

By using these techniques, visitors can interact (i.e., touch, manipulate, and rotate) with digital replicas of human remains in an immersive virtual environment, replacing passive observation [33]. One of the future developments of this project could concern its application on a museum case study, such as the Grottarossa Mummy, currently found in the Museo Nazionale Romano, and subjecting this to palynological analyses [34].



(**a**) (**b**)

Figure 2. (**a**) Use of immersive VR at the Maker Faire, a public event that facilitates and talks about technological innovation, held in Rome in 2022; (**b**) screenshot of the virtual environment of the application during the action (ego-view).

4. Conclusions

In this paper, we have illustrated an application of VR and 3D-printing techniques for the dissemination of archaeobotanical and bioanthropological content.

The pipeline of the study consists of four main steps, two for archaeobotany and two for bioanthropology: the creation of 3D digital models of three pollen grains and their 3D printing; the reconstruction of 3D skeleton replicas and the development of an interactive environment.

The first two phases involved the Blender modeling approach for creating 3D models of naked wheat, hazelnut, and daisy pollen grains using SEM images as references, and the optimization of 3D models for their materialization via 3D printing. The latter two focus on exploiting VA and VR to create 3D replicas of human bones and develop an interactive environment.

The high scores in user questionnaires for the presence, significance of exchanged knowledge, and overall experience appreciation, demonstrate that the project is effective in terms of content quality and usability.

The effectiveness of knowledge dissemination demonstrated in the appreciation and understanding of anthropological remains with immersive VR devices, and the possibility of creating 3D models of pollen grains with morphological reliability provide an opportunity for future development of serious games with bioarchaeological content. In general, the proposed work provides a framework for future research in this field, i.e., using VR for the dissemination and education of underexplored topics such as archaeobotany and bioanthropology.

We are aware that our study represents only a preliminary analysis of the advantages of 3D models and virtual reality for the study of bioarchaeological heritage. Future steps will certainly involve an evaluation and quantification of the impact of 3D technologies on the dissemination of palynology. In addition, we plan to include more options for people with disabilities, particularly in relation to the study of bioanthropological remains. Finally, we aim to apply the presented solutions on a museum case study, such as the Grottarossa Mummy stored in the Museo Nazionale Romano.

Author Contributions: Conceptualization, R.M., C.M. and S.G.M.; methodology, S.G.M., R.M., M.R.M. and G.C.; investigation: R.M., P.L.T., G.C. and C.M.; formal analysis, R.M.; resources, R.M., P.L.T., G.C. and C.M.; writing—original draft preparation, R.M., P.L.T. and C.M.; writing—review and editing, R.M., P.L.T., G.C., M.R.M., S.G.M. and C.M.; visualization, R.M., G.C., M.R.M. and C.M.; project administration, R.M. All authors have read and agreed to the published version of the manuscript.

Funding: The publication was produced with the co-funding of the European Union–Next Generation EU, PNRR PE 0000020 CHANGES (Cultural Heritage Active Innovation for Next-Gen Sustainable Society Extended Partnership) Spoke 8.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Canci, A.; Minozzi, S. *Archeologia dei Resti Umani*, 2nd ed.; Carocci Editore: Rome, Italy, 2015; pp. 11–12.
2. Little, M.A.; Sussman, R.W. History of Biological Anthropology. In *A Companion to Biological Anthropology*; Larsen, C.S., Ed.; Blackwell Publishing: Malden, MA, USA, 2010; Volume 1, pp. 13–38.
3. Licata, M.; Bonsignore, A.; Boano, R.; Monza, F.; Fulcheri, E.; Ciliberti, R. Study, conservation and exhibition of human remains: The need of a bioethical perspective. *Acta Biomed. Atenei Parm.* **2020**, *91*, e2020110.
4. Krigbaum, J. Bioarchaeology. In *Encyclopedia of Archaeology*; Elsevier: New York, NY, USA, 2008; pp. 924–927.
5. Mercuri, A.M.; Sadori, L.; Blasi, C. Editorial: Archaeobotany for cultural landscape and human impact reconstructions. *Plant Biosyst.* **2010**, *144*, 860–864. [CrossRef]
6. Simpson, M.G. Evolution and diversity of woody and seed plants. In *Plant Systematics*, 3rd ed.; Simpson, M.G., Ed.; Elsevier: New York, NY, USA, 2019; pp. 131–165.
7. Simpson, M.G. Palynology. In *Plant Systematics*, 2nd ed.; Simpson, M.G., Ed.; Academic press: London, UK, 2010; pp. 561–571.
8. Mercuri, A.M. Genesis and evolution of the cultural landscape in central Mediterranean: The 'where, when and how' through the palynological approach. *Landscape Ecol.* **2014**, *29*, 1799–1810. [CrossRef]
9. Mercuri, A.M.; Bandini Mazzanti, M.; Florenzano, A.; Montecchi, M.C.; Rattighieri, E.; Torri, P. Anthropogenic Pollen Indicators (API) from archaeological sites as local evidence of human-induced environments in the Italian peninsula. *Ann. Di Bot.* **2013**, *3*, 143–153.
10. Faegri, K.; Iversen, J. *Textbook of Pollen Analysis*; Wiley: Chichester, UK, 1989.
11. Baczyński, J.; Miłobędzka, A.; Banasiak, Ł. Morphology of pollen in Apiales (Asterids, Eudicots). *Phytotaxa* **2021**, *478*, 1–32. [CrossRef]
12. Weber, G.W.; Schäfer, K.; Prossinger, H.; Gunz, P.; Mitteröcker, P.; Seidle, H. Virtual Anthropology: The Digital Evolution in Anthropological Sciences. *J. Physiol. Anthropol. Appl. Human. Sci.* **2001**, *20*, 69–80. [CrossRef] [PubMed]
13. Profico, A.; Bellucci, L.; Buzi, C.; Di Vincenzo, F.; Micarelli, I.; Strani, F.; Tafuri, M.A.; Manzi, G. Virtual Anthropology and its Application in Cultural Heritage Studies. *Stud. Conserv.* **2018**, *64*, 323–336. [CrossRef]
14. Raja, R.; Nagasubramani, P.C. Impact of modern technology in education. *J. Adv. Res.* **2018**, *3*, 33–35. [CrossRef]
15. Avola, D.; Cinque, L.; Fagioli, A.; Foresti, G.L.; Marini, M.R.; Pannone, D. VRheab: A fully immersive motor rehabilitation system based on recurrent neural network. *Multimed. Tools* **2018**, *77*, 24955–24982. [CrossRef]
16. Mortara, M.; Catalano, C.E.; Bellotti, F.; Fiucci, G.; Houry-Panchetti, M.; Petridis, P. Learning cultural heritage by serious games. *J. Cult. Herit.* **2014**, *15*, 318–325. [CrossRef]
17. Zambanini, S.; Schlapke, M.; Hödlmoser, M.; Kampel, M. 3D acquisition of historical coins and its application area in numismatics. In Proceedings of the SPIE—The International Society for Optical Engineering, San Jose, California, USA, 25 February 2010; p. 7531.
18. Barsanti, S.G.; Malatesta, S.G.; Lella, F.; Fanini, B.; Sala, F.; Dodero, E.; Petacco, L. The WINCKELMANN 300 project: Dissemination of culture with virtual reality at the Capitoline Museum in Rome. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.—ISPRS Arch.* **2018**, *XLII*, 371–378. [CrossRef]
19. Micarelli, I.; Paine, R.; Giostra, C.; Tafuri, M.A.; Profico, A.; Boggioni, M.; Di Vincenzo, F.; Massani, D.; Papini, A.; Manzi, G. Survival to amputation in pre-antibiotic era: A case study from a Longobard necropolis (6th–8th centuries AD). *J. Anthropol. Sci. Rep.* **2018**, *96*, 185–200.

20. Karasik, A.; Rahimi, O.; David, M.; Weiss, E.; Drori, E. Development of a 3D seed morphological tool for grapevine variety identification, and its comparison with SSR analysis. *Sci. Rep.* **2018**, *8*, 6545. [CrossRef] [PubMed]
21. Pietroni, E.; Pagano, A.; Biocca, L.; Frassineti, G. Accessibility, Natural User Interfaces and Interactions in Museums: The IntARSI Project. *Heritage* **2021**, *4*, 567–584. [CrossRef]
22. Diethart, B.; Auer, W. *Triticum aestivum*. In PalDat—A Palynological Database. 2021. Available online: https://www.paldat.org/pub/Triticum_aestivum/304793 (accessed on 17 March 2023).
23. Halbritter, H.; Diethart, B.; Heigl, H. *Corylus avellana*. In PalDat—A Palynological Database. 2020. Available online: https://www.paldat.org/pub/Corylus_avellana/303765 (accessed on 17 March 2023).
24. Halbritter, H.; Heigl, H. *Bellis perennis*. In PalDat—A Palynological Database. 2020. Available online: https://www.paldat.org/pub/Bellis_perennis/304603 (accessed on 17 March 2023).
25. Blender. Available online: https://www.blender.org/ (accessed on 1 December 2022).
26. PalDat—A Palynological Database. (2000 Onwards). Available online: www.paldat.org (accessed on 1 December 2023).
27. Manzollino, R.; Malatesta, S.G.; Avola, D.; Cinque, L.; Del Bove, A.; Leopardi, L.; Marini, M.R. Enhancement and Communication of Ancient Human Remains through VR: The Case Study of Sexual Dimorphism in the Human Skull. *Heritage* **2023**, *6*, 4120–4133. [CrossRef]
28. Wilson, O.J. The 3D Pollen Project: An open repository of three-dimensional data for outreach, education and research. *Rev. Palaeobot. Palynol.* **2023**, *312*, 104860. [CrossRef]
29. Azzolino, M.C.; Brombin, O.; Cilento, A.; Lacirignola, A.; Rolli, R.; Tamarino, T. *Sensi e Parole per comprendere l'arte*; Prinp Editore: Turin, Italy, 2020.
30. Chatterjee, H.J.; Hannan, L. *Engaging the Senses: Object-Based Learning in Higher Education*; Routledge: New York, NY, USA, 2016.
31. Poce, A.; Re, M.R.; Valente, M.; De Medio, C. Using 3D reproductions of archaeological objects in museum education context. A learning experience within an Etruscan musical collection. *IMG J.* **2021**, *4*, 242–261.
32. Gensini, V. *Musei, Pubblici, Tecnologie*; Pisa University Press: Pisa, Italy, 2020.
33. Bonacini, E.; Giaccone, S.C. Gamification and cultural institutions in cultural heritage promotion: A successful example from Italy. *Cult. Trends* **2022**, *31*, 3–22. [CrossRef]
34. Ciuffarella, L. Palynological analyses of resinous materials from the roman mummy of Grottarossa, second century AD: A new hypothesis about the site of mummification. *Rev. Palaeobot. Palynol.* **1998**, *103*, 201–208. [CrossRef]