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From Seeds to Screen: A Brief Guide to Choosing Digital Assets for Historical Edugames

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ABSTRACT

This contribution examines the role of scientific coherence in virtual reconstructions of archaeological contexts, using archaeobotanical data as an illustrative example in the development of museum edugames within 3D environments such as Unity3D. It argues that historical reconstruction cannot be confined solely to architectural structures, but must extend to the anthropogenic and natural landscape, including plant species, agricultural practices, and environmental resources documented through archaeological, palaeobotanical, and isotopic evidence. This principle also applies to textures, vessels, and furnishings, which are often selected from standardized digital assets (such as the various "Roman packs 3D") available online at relatively low cost. The arbitrary use of such standardized digital assets, characteristic of commercial game design, risks generating anachronistic and culturally misleading representations, thereby undermining the scientific credibility of museum institutions. To a certain extent, this paper seeks to raise awareness among game designers, developers, software companies, and, more broadly, all relevant stakeholders (including academics, industry professionals, and policymakers) regarding the importance of adopting accurate and non-standard assets. It is, indeed, through careful attention to detail that a game acquires genuine educational value, rather than remaining merely a form of entertainment.

Keywords: Edugames, 3D environments, education, didacts, archaeobotany

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INTRODUCTION

The increasing diffusion of virtual reconstructions and educational games set in Historical and archaeological contexts calls for a rigorous methodological reflection on the scientific quality of digital cultural products. In the case of specific contexts (and every context is specific), three-dimensional reconstruction cannot be confined to the formal rendering of architectural structures; rather, it must be grounded in a coherent framework of archaeological, archaeobotanical, paleoenvironmental, and isotopic data capable of restoring the complexity of ancient anthropogenic and natural landscapes. Within this perspective, the selection of plant species, crops, environmental resources, furnishings, textures, and everyday objects should not be regarded as secondary decorative elements, but as integral components of a scientifically informed narrative. This contribution examines the role of methodological coherence in virtual reconstructions, using archaeobotanical data as an illustrative case study to develop museum edugames within 3D environments (Champion, 2021). Rather than presenting a single project or a closed experimental design, the paper develops its argument through a sequence of interconnected case studies. This approach allows the discussion of methodological issues emerging from real educational and heritage contexts, while simultaneously introducing readers to an evolving research field in which experimental archaeology and immersive laboratory-based learning increasingly overlap (Yin, 2018; Hurcombe, 2008).

Archaeobotany, through the analysis of seeds, pollen, and plant remains, provides concrete tools for reconstructing ancient diets, cultivation systems, and landscapes, thereby anchoring visual and narrative choices to documented evidence. Such an approach demonstrates that historical reconstruction must encompass the entire cultural ecosystem of the past, rather than relying on generic or stereotypical representations. Particular attention is devoted to the widespread and often uncritical use of standardized digital assets, such as commercially available "Roman 3D packs", offered at relatively low cost. While common in commercial game production, the arbitrary adoption of these assets in museum contexts risks introducing anachronisms, typological inconsistencies, and culturally misleading representations when they are not verified against specific chronological and geographical frameworks. The visual environment itself, beyond the textual content delivered by non-player characters (NPCs), functions as a powerful interpretative medium (Champion, 2015). Inaccurate or decontextualized assets, therefore, compromise not only aesthetic authenticity but also the institution's scientific credibility. In light of these issues, this paper emphasizes the necessity of a multidimensional and interdisciplinary approach to the design of edugames, supported by genuine scientific coordination. The establishment of a scientific advisory committee to oversee not only narrative content but also visual and environmental elements would help ensure methodological rigor, cultural quality, and educational accountability. Within this framework, the choice between purchasing turnkey digital solutions and developing projects internally or through co-design with universities and research centers is not merely an economic decision, but an epistemological one: it directly affects the degree of control over the scientific coherence of the final product. Three-dimensional reconstruction in museum contexts cannot therefore be reduced to scenographic design nor rely on generic digital repositories. It constitutes an interpretative act grounded in evidence, requiring integrated expertise and a clear assumption of scientific responsibility toward both the academic community and the broader public. It is also important to clarify in this introduction that *museum education* does not concern museums in the narrow sense alone, but also encompasses archaeological sites, archaeological parks, and cultural heritage sites more broadly. Within these contexts, museum education plays a fundamental role in heritage mediation, valorization processes, and the construction of accessible and inclusive learning environments and experiences (Jonassen, 1999) through the right devices, environments, and artifacts (Parmigiani, 2013), learning mediators (Damiano, 2013), and storytelling (Ohler, 2008). This broader understanding is consistent with the framework promoted by UNESCO (2024), which recognizes cultural heritage, including archaeological sites, as a crucial educational resource for sustainable development, intercultural dialogue, and global citizenship. Similarly, ICOM, the *International Council of Museums*, defines the museum as a permanent institution in the service of society and its development, emphasizing the educational and social function of museums and heritage institutions, thereby encompassing archaeological contexts as well. In this regard, the establishment of the *International Committee for Museums and Collections of Archaeology and History* (ICMAH, 2024) is demonstrative of a broader conceptualization of museums.

It is important to emphasize that the present contribution reports on an ongoing line of research that is still under development, both theoretically and methodologically. The interdisciplinary nature of the work,

situated at the intersection of archaeology, experimental archaeology, archaeobotany, heritage studies, museum education, and digital game-based learning, necessarily entails an exploratory dimension (Hurcombe, 2008; Champion, 2021). Consequently, the objective of this paper is not to propose a definitive methodological framework or a fully validated operational model, but rather to identify a set of critical issues, research directions, and methodological principles that emerge from the integration of these different fields.

More specifically, the paper adopts a case-study-based approach. A sequence of illustrative examples is presented not merely to describe individual experiences but to make intelligible a frontier research area at the crossroads of experimental archaeology and laboratory-based teaching through immersive virtual environments (Yin, 2018; Hurcombe, 2008; Champion, 2021). The selected cases, drawn primarily from Roman archaeological contexts in Campania, are intended to demonstrate how scientific evidence, environmental reconstruction, and educational design may converge within virtual reality experiences and museum edugames.

From this perspective, the virtual environment is not conceived simply as a technological tool for visualization, but as a laboratory space in which hypotheses concerning historical reconstruction, environmental authenticity, and heritage mediation can be explored and discussed (Champion, 2015; Champion, 2021). The examples analyzed, therefore, serve both as empirical illustrations and as opportunities to reflect on broader epistemological and pedagogical questions related to the responsible use of immersive technologies in cultural heritage education (Chapman, 2016). Several of the methodological structures and validation procedures that may be expected in more mature research programs are therefore beyond the scope of the present study and constitute a subject for future investigation. In this sense, the contribution should be understood as a preliminary step towards developing a more comprehensive theoretical and methodological framework to support the scientific design and evaluation of historically grounded educational virtual environments.

"Cultivating" Accuracy

To demonstrate how the principles of scientific coherence discussed above can be applied in practice, the analysis now turns to a series of specific illustrative cases. These examples highlight the importance of contextualized evidence in guiding the selection of digital assets for educational virtual reconstructions. The exemplary cases considered are the Roman villas located in Campania (Italy). These examples are broadly generalizable to the wider Mediterranean basin. Let us imagine an ordinary day, merely a few years before the eruption of Mount Vesuvius. In the sunlit streets and terraced gardens of Pompeii and Herculaneum, life unfolded in a delicate harmony of earth, water, and human care. Vineyards clung to the slopes of Vesuvius, grapes ripening under the warm Mediterranean sun, while fig trees and walnut groves dotted the city's gardens, their fruits offering sweetness and sustenance. Broad fields of fava beans (precisely those that Pythagoras detested so much and which he and his followers were forbidden to eat) enriched the soil and nourished the inhabitants, while cereals, wheat, and barley, arrived from neighboring lands or across the seas, carried along the bustling trade routes of the Bay. Olive trees, their branches heavy with fruit, yielded golden oil that dripped into amphorae, linking daily meals with rituals of commerce and craft. The rhythms of the seasons, the cycles of rain and drought, shaped the very flavors of the Campania region in southern Italy, blending local cultivation with the whispers of distant lands. Animals shared this vibrant world. Bovines grazed the floodplains and terraces; goats and sheep browsed orchards and pastures, their movements sculpting the landscape itself. Pigs foraged near human dwellings, consuming roots, scraps, and acorns, while chickens pecked through carefully measured grains, sometimes enriched with millet. We reflect on a previous initiative undertaken by the Department of Human, Philosophical and Educational Sciences to enhance the edugames developed with Unity 3D, using a 3D model provided by the Virtual Museum of Herculaneum (www.museomav.it) under an agreement signed between the two institutions. In that context, the standard flowerbeds in the Villa of the Papyri (Todino et al., 2017; Todino et al., 2018) were replaced with reconstructions of laurel beds. Laurel, a plant highly valued in Roman culture, was selected not only for its fragrant qualities and medicinal properties, such as relieving stomach ailments when prepared as a decoction, but above all for its symbolic significance, as it crowned victors. The adoption of appropriate digital assets enhances verisimilitude, and increased verisimilitude supports the acquisition of accurate conceptual knowledge (Todino, 2024; Bilotti et al., 2025; Todino & Campitiello, 2025). This initial edugame served as a model for subsequent laboratory projects and informed broader theoretical reflections (such as those advanced in the present work) on selecting digital assets from the plant kingdom for integration into 3D environments.

Scientific Coherence and Environmental Authenticity in Virtual Reconstructions

In advanced historical reconstructions, such as those of Roman imperial villas, scientific coherence cannot be confined solely to architectural structures or decorative apparatuses, but must necessarily extend to the anthropogenic and natural landscape that surrounded and qualified the inhabited space. Contemporary archaeology no longer focuses exclusively on the excavation of artifacts; rather, it integrates data derived from disciplines such as archaeobotany, palynology, and the study of ancient seeds, thereby enabling increasingly accurate reconstructions of the plant species that were actually cultivated or used ornamentally in specific historical periods. In the case of sites such as the Pausilypon in Naples, this approach is currently applied through the controlled reintroduction of plant species compatible with the Roman context, with the aim of restoring not only the site's spatial form but also its overall environmental experience. When this principle is applied to virtual reconstruction and museum edugames developed in 3D environments such as Unity, it becomes evident that it is methodologically unsound to introduce trees, plants, or landscape elements based solely on aesthetic or ludic criteria, as is typical in entertainment-oriented video games. In the case of Pompeian villas, it is important to show the actual height and shape of Vesuvius before the eruption, and to depict Capri and the other islands along the coast in the distance. A Roman villa is not just a neutral setting, but rather a complex system in which architecture, gardens, fishponds, nymphaea, and productive areas respond to precise economic, symbolic, and social logics. The arbitrary use of vegetation would compromise the site's historical intelligibility, transforming the reconstruction into an anachronistic and culturally misleading representation. The villa of Publius Vedius Pollio, the aforementioned one in Pausilypon (cultura.gov.it/luogo/villa-di-vedio-pollione), is an emblematic case in this respect. The presence of fishponds, likely intended also for the breeding of moray eels (a practice widespread in aristocratic seaside villas), should not be interpreted as an expression of exceptional cruelty suggested by later legend, but rather as part of a well-documented economic and cultural practice.

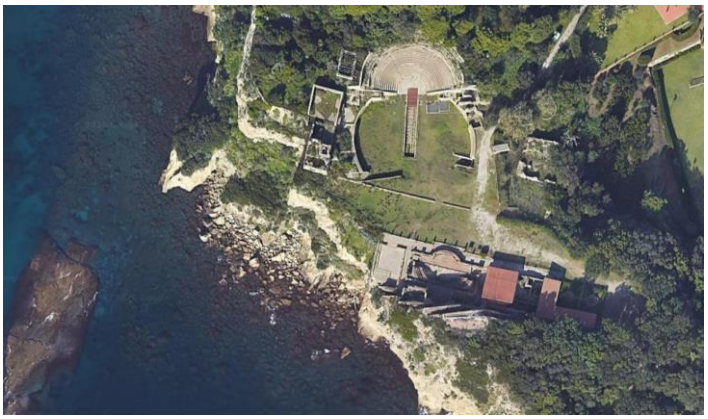

Figure 1. *Satellite view of the Pausilypon archaeological park (Villa of Vedio Pollione), Napoli (Italy).*

Figure 2. *Satellite view of the Pausilypon archaeological park (Villa of Vedio Pollione). In this image, you can see the coastline stretching to Gaiola, Napoli (Italy).*

A possible 3D virtual reconstruction of such spaces must therefore take into account not only their architectural configuration, but also the environmental and productive context in which they were embedded: water basins supplied with seawater or freshwater, coastal vegetation compatible with the climate and landscape of the first century BCE, and functional routes connecting the villa, the fishponds, and representational spaces. In this sense, the presence or absence of specific plant species directly contributes to an informed understanding of the economic and dietary practices of the Roman elite. Similarly, the villa of Cocceius Nerva at Bonea, located on the slopes of Mount Taburno in the Caudine Valley, should be reconstructed as being surrounded by olive groves and vineyards, specifically of indigenous varieties. This villa is also renowned for being mentioned by Horace (*Satires*, Book I, Satire V) in his account of the journey on the Via Appia, the "Regina Viarum". An undisputed testament to the site's importance is the marble statue of a satyr accompanied by a panther. The sculpture is currently housed in the National Archaeological Museum of Naples. Excavations at the site

also brought to light terracotta artifacts, coins, and glass fragments. A satyr or, more correctly, a youthful Dionysus holding a panther, comparable to a closely related statue housed in the National Archaeological Museum of Nola. This parallel specimen was recovered from the celebrated villa near Somma Vesuviana, generally identified as the residence in which Augustus spent his final days.

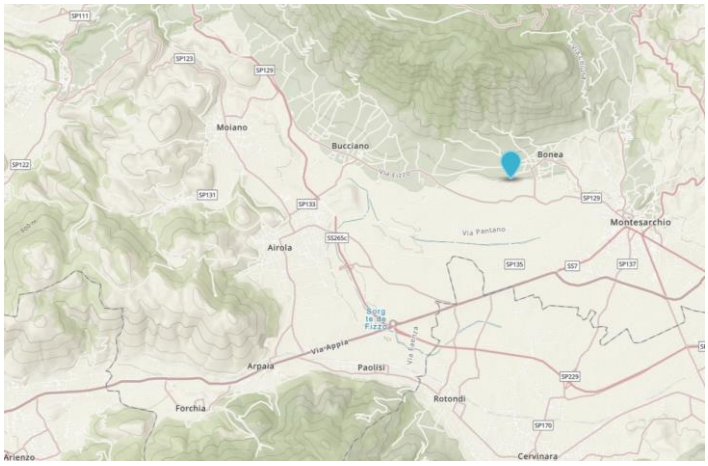

Figure 3. *Satellite image (terrain map) showing the location of the Villa di Cocceio, located near the cemetery of Bonea. Its position is protected by the Taburno massif behind it (to the north), while to the left (west) lie the Caudine Forks (close to Arpaia), leading towards Benevento and then on to the ports of Puglia. To the south lies the Partenio. The villa had a large, very sunny area with fertile lush fields. https://ngmdb.usgs.gov/topoview/viewer/#18/41.07076/14.61016*

Figure 4. *The Villa of the Papyri at Herculaneum should be represented, as has indeed been done at the Virtual Archaeological Museum of Herculaneum (MAV) www.museomav.it*

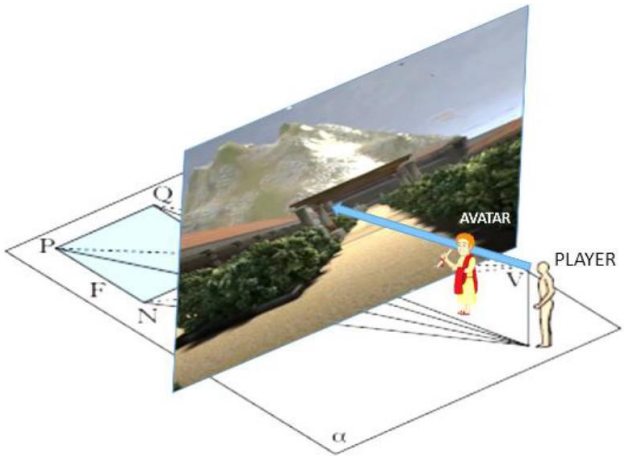

Figure 5. *Realism is an important factor to consider when a visitor is transported into a virtual world that recreates a historical environment.*

Likewise, the Villa of the Papyri at Herculaneum should be represented, as has indeed been done at the Virtual Archaeological Museum of Herculaneum (MAV), in its likely form in antiquity, not only with its papyrus scrolls but also with the plant species that actually adorned specific areas of the residence. Within a museum edugame, such reconstruction choices become opportunities for critical learning. Learners can be guided to understand how the selection of plant species, like that of building materials or construction techniques, results from empirical knowledge, available resources, and strategies of social and political self-representation. From a pedagogical perspective, this approach reinforces the distinction between ludic and historical realism, thereby fostering critical thinking. Making the reconstruction choices explicit. For instance, by indicating which plant species are archaeologically attested, which are hypothesized, and which are excluded, it thus educates the virtual visitor-user about the interpretative nature of historical knowledge. In this way, the edugame does not merely "display" a Roman villa, but teaches users to read the past as a complex system grounded in material evidence, textual sources, and experimental practiced, in close analogy with the methods of field archaeology, i.e., coherence between archaeology as practised in the field and virtual reconstruction emerges as an indispensable requirement for contemporary museum education. What has been said so far serves to demonstrates that, just as modern archaeological sites adopt carefully selected seeds and plant species to restore the original historical landscape, so too must digital reconstructions and museum edugames adhere to rigorous philological criteria, avoiding the arbitrary solutions characteristic of commercial game design. Here, "contextual design" (Beyer & Holtzblatt, 1998) means defining customer-centered systems that focus on the museum or archaeological site and its uniqueness. For

example, a statue of Aphrodite is not just any statue, but one from that particular place with its own unique characteristics. The administration, director, and curator want to highlight the aspects that distinguish it from other statues depicting the same subject.

No Tomatoes in Pompeii: A Brief History of Anachronism

It must be acknowledged that error is an inherent component of any intellectual and creative process, and that improvement often emerges precisely through the critical examination of one's own mistakes (Carofiglio, 2024). In this sense, errors may almost be "praised", insofar as they stimulate reflection, foster methodological awareness, and ultimately promote progress. For instance, when confronted with a museum edugame in which cultural heritage objects had been inaccurately scaled, we found ourselves in a position of considerable methodological concern. Such inconsistencies not only compromise visual coherence but also risk distorting users' perception and understanding of historical artifacts. Episodes of this kind underscore the importance of critical evaluation and continuous revision in the development of digital heritage applications. Even within the context of video game design, error can take on a formative value (Gee, 2013), particularly when it concerns superficial choices in selecting and integrating digital assets in historically themed video games. When programmers and game designers adopt quick solutions without adequately consulting historiographical sources or subject-matter experts, this may result in inaccurate or anachronistic representations. Yet precisely such mistakes can become opportunities for critical revision and project improvement. As Benes et al. (2017) argue, error, when acknowledged and examined, can serve as a pedagogical tool that activates reflective and corrective processes. From a broader epistemological perspective, knowledge (even when embedded in cultural and digital products) develops through an ongoing process of scrutiny and reformulation (Popper, 2024). In educational contexts, this dynamic is particularly relevant: discussing inaccuracies in historical video games can encourage users to adopt a critical stance toward representations of the past, fostering greater interpretive awareness (Corson, 1985). In this sense, even designers' mistakes, if addressed critically and collaboratively, can contribute to professional and cultural growth, transforming initial inaccuracies into opportunities for learning. Let us now turn to the seemingly unusual title of this section, No Tomatoes in Pompeii, which highlights the theme of historical anachronism, and to the rationale that prompted the study's conception. Sometimes, the aforementioned programmers and game designers, as well as people working in archaeological sites, meaning simple workers, are not well prepared to avoid making even simple mistakes. A few months prior, within the broader framework of these reflections, a visit was made to Pompeii to attend the exhibition Essere donna nell'antica Pompei ("Being a Woman in Ancient Pompeii"), organized in part with the help of several university colleagues. The exhibition, hosted at the *Palestra Grande* of Pompeii from 16 April 2025 to 31 January 2026, offered a comprehensive and nuanced exploration of women's lives in antiquity. During the visit to the adjacent domus, particular attention was paid to the restored gardens, many of which have been rehabilitated through carefully designed experimental-archaeology practices (Coles, 1979; Mathieu, 2002; Ceppatelli, Godino & Montelatici, 2013).

This initiative forms part of a broader strategy to recover the numerous green spaces within the archaeological site (both central and peripheral) that are currently unused or underutilized. The project not only seeks to protect and enhance the biodiversity of the Archaeological Park of Pompeii, but also to promote the agricultural regeneration of the surrounding territory as a key component of sustainable environmental management.

Figure 6. *In Domus Octavii Quartionis (Regio II in Pompeii), sophisticated work has been carried out to immerse visitors in a plausible reconstruction of the garden (photo by Michele Domenico Todino).*

Figure 7. *Domus Octavii Quartionis (photo by Michele Domenico Todino).*

Within this context, an informal exchange with site personnel offered a revealing example of how anachronistic assumptions about the past can easily emerge. A casual remark alluding to the presumed abundance of ancient banquets and the absence of tomato-topped pizza was met with a light-hearted affirmation. While the exchange remained amicable, it nonetheless highlighted a widespread misconception concerning historical foodways.

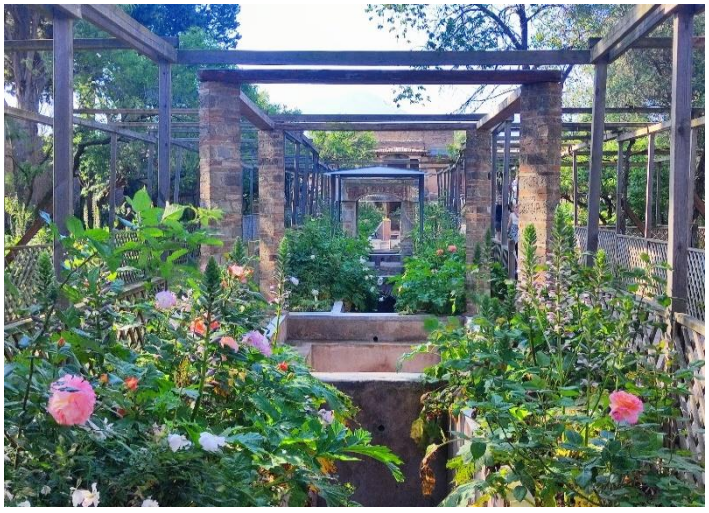

Figure 8. *Domus Octavii Quartionis (photo by Michele Domenico Todino).*

Figure 9. *Regio II in Pompeii (photo by Michele Domenico Todino).*

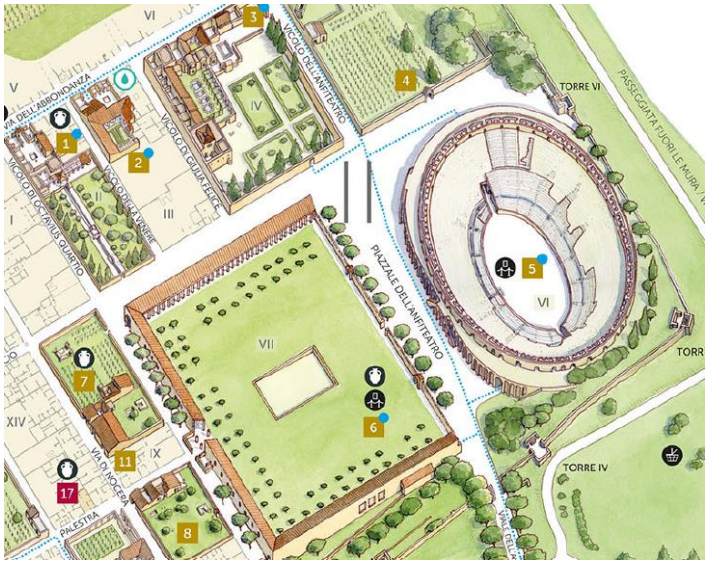

Figure 10. *Domus Octavii Quartionis (Regio II in Pompeii),*

Indeed, had the interlocutor been familiar with the history of the tomato in Europe, it would have been clear that this ingredient was introduced only in the first half of the sixteenth century.

In Spain, its initial reception was limited, and it has been hypothesized that early European varieties contained high levels of solanine, rendering them unsuitable for regular consumption. As a result, the tomato was first cultivated primarily for ornamental, medicinal, or botanical purposes, and its diffusion remained restricted for several decades. Only later processes of selective breeding rendered it fully edible. Italy became the first European region after Spain to develop a sustained familiarity with the tomato, largely due to the political and dynastic connections between the Bourbon monarchy and other ruling families, as well as to Spanish dominion over several Italian

territories. Consequently, despite the vast geographical extent of the Roman Empire, the inhabitants of ancient Pompeii could not have consumed pizza as it is known today. Their diet may have included flatbreads comparable to pita, but without tomato as a topping. This example underscores the importance of maintaining strict historical and environmental accuracy in both physical and virtual reconstructions of the past, particularly within educational and museum contexts, where seemingly minor inaccuracies may significantly distort historical understanding. A predominantly commercial approach to video game development, when applied without appropriate adaptation to museum education and the enhancement of cultural heritage, risks producing outcomes that conflict with museums' scientific, educational, and institutional missions. The commercial game design paradigm is primarily oriented toward entertainment, rapid production cycles, aesthetic recognizability, and cost optimization (Austerberry, 2012; Banta, 2016; Kaal, Evans & Howe, 2021), rather than toward historical accuracy, interpretative depth, and cultural responsibility. Within this framework, visual plausibility is often conflated with historical realism, resulting in environments that merely "appear ancient" but are not grounded in reliable archaeological, philological, or environmental evidence. The use of standardized assets, widely distributed through digital marketplaces, constitutes one of the most significant sources of critical concern. These assets, designed for reuse in generic contexts, frequently incorporate stylistic, material, and landscape elements that are anachronistic or culturally indeterminate. The Villa Regina, located in Boscoreale within the Vesuvian hinterland and included in the archaeological circuit of the Parco Archeologico di Pompei, represents one of the most significant examples of a Roman *villa rustica* devoted to agricultural production, and at the same time another example in which archaeologists have reproduced the plant elements that complement the visitor's experience. Nearby, the Antiquarium of Boscoreale preserves artifacts and organic remains that illuminate the environmental, economic, and social context of rural life in this fertile territory. The materials on display (many of which were exceptionally well preserved by the eruption of AD 79) provide valuable insight into cultivation practices, storage systems, and the daily activities that structured the region's agricultural economy. Surrounding the excavated structures of Villa Regina, a replanted vineyard now extends across the site. This modern cultivation is based on archaeological and archaeobotanical evidence, including casts of ancient vine roots preserved in the volcanic deposits. The vineyard offers a tangible reconstruction of the ancient agricultural landscape, enabling visitors to visualize the estate as it would have appeared prior to the eruption. It reinforces the interpretation of the villa as a working production center deeply integrated into the viticultural economy of the Vesuvian area. This productive character clearly distinguishes Villa Regina from the Roman concept of the *villa otium*.

Figure 11. *Rural villa near Villa Regina, originally built in the 1st century B.C. and expanded in the Augustan and Julio-Claudian periods, the villa preserves a wagon (plaustrum), agricultural traces from 79 A.D., replanted vineyards, and visible pyroclastic layers from the eruption that destroyed the farm (photo by Michele Domenico Todino).*

Figure 12. *Rural villa near Villa Regina, arranged around an open courtyard with a wine cellar containing 18 dolia. The complex includes a portico, storage rooms, a torcularium with a wine press, a decorated triclinium, a kitchen, a cistern, a granary, and a barnyard (photo by Michele Domenico Todino).*

In Roman cultural and social ideology, a *villa otium* was conceived as a residence dedicated to leisure, intellectual pursuits, and aristocratic self-representation. A paradigmatic example is the Villa of Poppea at Oplontis, traditionally attributed to Poppea Sabina, the second wife of Nero, and renowned for its monumental architecture, refined decorative schemes, and expansive gardens. Such residences embodied the values of elite leisure and cultivated withdrawal from urban political life. By contrast, Villa Regina exemplifies a *villa negotium* (such as that of the

Caudine Valley already described, or the ancient Roman villa of Faragola, although very luxurious, which managed agricultural land): a rural establishment organized primarily for economic production and estate management. In the case of Villa Regina, the presence of facilities for wine production and storage (such as presses, dolia, storage rooms, and service areas) demonstrates the complex's functional and entrepreneurial nature. The reconstructed vineyard, therefore, not only enhances the visual comprehension of the site but also underscores the fundamental distinction in Roman society between villas designed for otium and those structured around negotium, where agricultural labor and productivity formed the core of daily life.

From "Buy or Make" to Academic Co-Design: Ensuring Scientific Rigor in Museum Edugames

When such resources are introduced into museum-based historical reconstructions without appropriate scientific mediation, the outcome is a stereotyped representation of the past that flattens the site's historical and territorial specificity. In the museum context, this may result in evident inaccuracies (such as inappropriate vegetation, out-of-context objects, or arbitrary architectural solutions) that undermine the institution's scientific credibility and compromise its authority in the eyes of both the public and the academic community. Even more problematic is the design of edugames entrusted to development teams lacking an interdisciplinary structure. In the absence of archaeologists, historians, pedagogists, conservation specialists, and cultural heritage experts, design decisions are inevitably driven by aesthetic or functional criteria typical of the commercial video game industry, rather than by methodological and scientific considerations. This can lead to excessive simplification, sensationalistic narratives, or undocumented interpretations, all of which are incompatible with museums' educational role. In such cases, museums may find themselves in the uncomfortable position of having to justify digital products that convey distorted or misleading information, thereby exposing directors and curators to well-founded criticism. From an institutional perspective, these shortcomings can generate significant awkwardness. Museums, as institutions responsible for the protection, research, and dissemination of cultural heritage, must ensure the accuracy and reliability of the content they present to the public. An edugame that exhibits clear historical or environmental inconsistencies risks contradicting the museum's physical exhibitions, scientific catalogs, and educational activities. Such dissonance not only weakens the coherence of the cultural offer but may also erode the trust of visitors, scholars, and funding bodies. Consequently, the uncritical adoption of models and practices derived from commercial game design, combined with the indiscriminate use of standardized assets and the absence of interdisciplinary coordination, may result in digital experiences that are inadequate or even detrimental within the museum context. By contrast, the design of edugames for museums requires a fundamentally different approach: one that is slow, reflective, scientifically grounded, and pedagogically oriented, in which technology and play are not ends in themselves but instruments serving knowledge production, cultural responsibility, and institutional credibility. A further critical issue, closely connected to the problems outlined above, concerns the well-known buying or doing dilemma (Mintzberg, 1996; Daft, 2004), that is, the choice between acquiring ready-made digital products available on the market and developing solutions internally, or through co-design, specifically tailored to the museum context. In the field of educational video games and virtual reconstructions for cultural heritage, adopting commercially packaged "turnkey" solutions may initially appear advantageous in terms of cost, time, and ease of implementation. However, this choice often entails a loss of control over scientific content, educational methodologies, and the cultural implications of the final product, thereby exposing museums to the risk of adopting tools that are not fully aligned with their institutional mission. Within this framework, universities can play a decisive role in bridging the gap between institutional needs and specialized expertise. Owing to their intrinsically interdisciplinary nature, academic environments can integrate competencies from archaeology, history, pedagogy, educational sciences, digital humanities, game design, and immersive technologies (Coppola & Zanazzi, 2020).

This convergence allows the design of museum edugames to be addressed not merely as a technical or creative challenge, but as a complex cultural process grounded in scientific rigor, methodological awareness, and educational responsibility. Choosing a doing model, or hybrid forms of co-design involving museums, universities, and technological partners, enables the development of highly contextualized digital products built on the specific characteristics of the site, collections, and target audiences. In this regard, universities provide not only theoretical expertise but also highly qualified professionals, such as researchers, doctoral candidates, and postdoctoral fellows, as well as applied research laboratories, capable of ensuring continuous oversight of the project's scientific and pedagogical quality. This significantly reduces the risk of anachronistic errors, improper simplifications, or arbitrary

aesthetic solutions typically associated with purely commercial approaches. Moreover, collaboration with universities allows museums to adopt a medium- to long-term perspective oriented toward experimentation, evaluation, and continuous revision of digital products. Unlike the commercial video game market, which privileges rapid production cycles and consumption-driven logic, the academic context fosters reflective, documented, and replicable processes aligned with the principles of scientific research. In this sense, universities function not merely as providers of expertise but as guarantors of cultural quality, capable of safeguarding museums from choices that, although seemingly efficient in the short term, may ultimately result in institutional embarrassment and a loss of credibility. Ultimately, the buying-versus-doing dilemma cannot be addressed solely on economic or operational grounds. In the field of digital museum education and historical reconstruction, it entails a profoundly cultural and strategic choice. The involvement of universities, through models of co-design and applied research, represents one of the most effective responses to ensuring that ludic-digital technologies genuinely serve knowledge production, i.e., becoming a genuine educational mediator (Damiano, 2013), heritage "virtual protection", and the educational "responsibility" of museums. The term is placed in quotation marks because the primary value remains inherently associated with the physical artifacts themselves. Nevertheless, digital technologies possess significant educational and interpretative value insofar as they function as mediating tools, fostering visitor engagement and encouraging reflection through the virtual representation and contextualization of cultural objects within game-based learning environments.

A possible definition of archaeobotany

Let us now look at a practical example and provide some concrete definitions (which can be used to choose the right stones and woods for the textures, the correct shape of the oil lamps, from which the light spreads throughout the rooms, and anything else). Archaeobotany, by studying seeds, pollen, and plant remains at archaeological sites, allows us to discern these details with precision, revealing what was actually cultivated, consumed, and discarded (Murphy et al., 2013; Rowan, 2017). Thus, the analysis of food waste and Pompeian gardens provides valuable insights into diets, agricultural practices, and food preparation methods, offering the possibility of reviving ancient culinary traditions. In this sense, even a simple ironic remark about the tomato becomes a prompt for reflecting on how archaeobotanical knowledge can connect us to the flavors, landscapes, and lifestyles of the past. Analysis of plant remains revealed a standard Mediterranean diet, including wheat, barley, legumes, olives, grapes, and figs. Less common varieties, such as millet, also emerged, suggesting a certain dietary diversity. However, most of the samples came from secondary fillings or building materials, indicating that Pompeian dwellings were not centers of agricultural processing. This suggests that cereals and legumes were purchased ready for consumption rather than grown or processed locally. Similarly, the germination of 2,000-year-old palm seeds from archaeological sites in the Judean desert (Sallon & Alii, 2020) offers a unique opportunity to study the date palm, described in antiquity for the quality, size, and medicinal properties of its fruits, but lost for centuries.

Integrating archaeobotanical evidence with immersive virtual reconstructions

Connecting archaeobotany with immersive educational environments developed in Unity 3D offers a powerful approach to both research and pedagogy. Archaeobotany, by analyzing seeds, pollen, and other plant remains from archaeological sites, generates complex datasets that are often difficult to interpret through traditional two-dimensional media. Translating these data into interactive three-dimensional models allows patterns in cultivation, consumption, and waste disposal to be visualized with unprecedented clarity. Immersive virtual reconstructions of ancient spaces, such as the urban streets, gardens, and domestic interiors of Pompeii or the luxurious Villa dei Papiri in Herculaneum, enable students and researchers to explore these environments firsthand, observing how plant cultivation and landscaping shaped daily life, diet, and social practices. Moreover, virtual reality provides an active learning context in which users are not mere observers but participants. They can interact with reconstructed gardens, collect virtual seeds, or simulate the preparation and storage of foods, thereby gaining an embodied understanding of ancient agricultural and culinary practices. This immersive engagement facilitates a deeper comprehension of processes that textual or two-dimensional representations alone cannot convey. The use of Unity 3D also enables the reconstruction of fragile or partially inaccessible sites, safeguarding original artifacts while making knowledge broadly available. By simulating alternative historical scenarios, such as variations in garden layout or crop distribution, these virtual environments can support both research hypotheses and educational exploration, bridging scientific data with experiential learning.

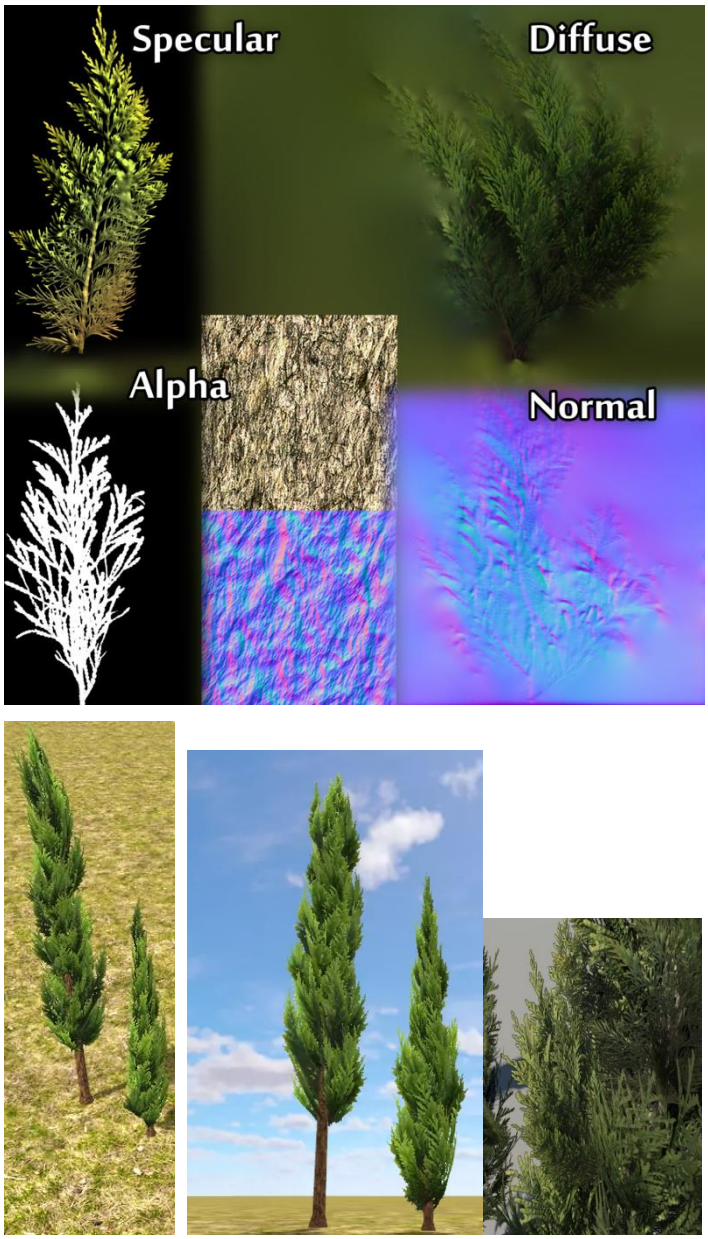

Figure 13. *It is possible to find the right digital assets, but it takes a lot of time to search for them. Here is a very detailed example of Italian Cypress (Source: Image available at https://assetstore.unity.com/packages/3d/vegetation/trees/italian-cypress-low-poly-tree-pack-18571)*

Integrating archaeobotany with immersive technologies fosters interdisciplinary collaboration, combining expertise from archaeology, botany, history, and digital technology. In this context, archaeobotanical research provides the empirical content, while Unity 3D offers the medium through which this knowledge becomes an interactive and sensorially rich experience. Such integration not only enhances understanding of the ancient world but also cultivates appreciation for its environmental, dietary, and cultural dimensions in a manner that is both rigorous and pedagogically innovative. It should be emphasized that the inclusion of a link to a digital asset (in this case, a cypress tree typical of southern Italy) is intended solely as an illustrative example. The objective of this paper is not to provide an inventory of downloadable resources or a navigational guide to digital asset repositories. Instead, the focus is on outlining the methodological framework required to design historically accurate edugames, namely, adopting a research-driven approach analogous to that employed in archaeobotanical investigations to reconstruct past environments.

For a historically accurate edugame

In the sun-drenched streets and courtyards of Pompeii and Herculaneum, the everyday fare of their inhabitants reveals a rich tapestry of tastes, textures, and seasonal rhythms, as recently illuminated by isotopic analyses published in *Scientific Reports*. The fertile slopes of Vesuvius were adorned with vineyards and fig trees, their fruits ripening in warm Mediterranean light, while broad fields of fava beans enriched the soil and the tables of the city alike. Cereals, though essential to the Roman diet, often arrived from neighboring regions or distant provinces, traveling along the busy maritime arteries of the Bay of Naples. Olives, pressed into golden oil, dripped into amphorae, while gardens and orchards whispered of walnuts, figs, and imported dates, forming a subtle symphony of local and traded flavors. The animal diet complemented this botanical abundance: bovines, sheep, and goats grazed in floodplains and terraces; pigs roamed near human settlements, foraging among scraps and roots; chickens were fed carefully, sometimes even with millet, and dogs scavenged with a consistent omnivorous rhythm. Fish, drawn from coastal waters, estuaries, and lagoons, added a delicate, briny counterpoint, their isotopic signatures reflecting the diversity of marine habitats and feeding strategies. Together, these plants and animals created a culinary landscape of remarkable variety, complexity, and interconnection with the land and sea. For an educational game seeking fidelity to this ancient world, these insights suggest a design that goes beyond superficial "Roman food" iconography. Players could cultivate terraces of grapes and fava beans, manage fig orchards, or press olives into virtual amphorae, observing the effects of irrigation, soil enrichment, and seasonal cycles. Animal husbandry could be interactive: guiding pigs to forage, feeding chickens specific grains, rotating grazing lands for sheep and goats, and harvesting fish from varied aquatic zones with distinct behaviors. Such mechanics, rooted in archaeobotanical and isotopic research, would allow learners to taste (virtually) the rhythms of Roman life (Angela, 2010, 2024), linking diet, environment, and trade in

a sensorially rich, scientifically informed recreation of Pompeii and Herculaneum.

From Virtual Tours to Interactive Edugames in Cultural Heritage Dissemination: A Brief Discussion

Let us now highlight a few points. It is important to emphasize that undertaking these methodological steps with rigor serves as a constant reminder that we are operating within the field of cultural heritage promotion and dissemination. Digital reconstruction is not merely a technical exercise, but a responsibility toward the interpretation and transmission of historical knowledge. In this regard, enabling virtual access to geographically distant or physically inaccessible sites represents a significant opportunity. The development and distribution of downloadable or online edugames allows users to engage with cultural heritage beyond spatial and temporal constraints. It must also be stressed that an edugame is conceptually and functionally distinct from a virtual tour. Virtual tours typically rely on semi-static camera systems that limit user interaction to predefined viewpoints. By contrast, immersive environments developed on platforms such as Unity 3D allow for dynamic exploration, interaction with objects and environments, process simulation, and the integration of narrative and problem-solving activities. Such environments provide a far more comprehensive and pedagogically meaningful experience. By allowing students to download or access these edugames online, students are offered genuine opportunities for distance learning, enabling them to explore places distant in space and time, and, in some cases, no longer physically extant. Moreover, virtual reality environments can be accessed anytime, anywhere, offering flexibility, accessibility, and cost-effectiveness. When grounded in scientific rigor, these tools become powerful instruments for inclusive education and for the responsible dissemination of cultural heritage knowledge.

CONCLUSION

All of this is increasingly possible at the Archaeological Park of Pompeii, due in no small part to the commitment of its Director, Gabriel Zuchtriegel, who has invested significantly in integrating the historical and scientific dimensions of various ancient cultivations. One notable example is vineyards and wine production, which have even led to the establishment of a functioning winery within the park itself (Direzione Generale Musei Parco Archeologico di Pompei, 2025). As Alberto Angela eloquently illustrates in his 2010 work *Impero: Viaggio nell'Impero romano seguendo una moneta*, in which a single coin travels through Baiae (located in close proximity to Pompeii) and then re-aired in a television special dedicated solely to Pompeii, filmed entirely in a single sequence shot lasting over two hours, which traverses the archaeological area of Pompeii following Alberto Angela in his exploration without any cuts or interruptions and interacting several times with Gabriel Zuchtriegel (Angela, 2024), one must first immerse oneself through imagination before doing so via virtual reality. Imagination enables us to envision the past, and this creative process has inspired renowned filmmakers and prominent game designers, who, in turn, have influenced new generations of archaeologists. These archaeologists, empowered by emerging technologies, are now making discoveries once thought impossible. Consider, for example, the reading of carbonized papyri through artificial intelligence. But where do such inspirations originate? We remain convinced of the central role of schools, which, from the earliest primary years, can (through effective pedagogical methods, appropriate technologies, and the passion of dedicated teachers) ignite children's curiosity about history and the past of that extraordinary basin of water and life we call the Mediterranean. In conclusion, this paper calls for a renewed ethical and pedagogical commitment by game designers, developers, software companies, and all relevant stakeholders (including academics, industry professionals, and policymakers) to adopt accurate thoughtfully curated, non-standard assets. Such a commitment aligns with the core values promoted by UNESCO and ICOM, particularly the principles of cultural authenticity, heritage safeguarding, inclusivity, and responsible knowledge dissemination. By embracing these values, digital games can move beyond mere entertainment to become meaningful educational tools, that foster critical awareness, intercultural dialogue, and respect for cultural diversity in accordance with internationally recognized standards of heritage stewardship and pedagogy.

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Ethics Committee Approval: This study falls within the University's mission to promote culture. In Italy, this is

defined as the "third mission" (after teaching and research), which is the university's mandate alongside research and teaching, focusing on the transfer of knowledge for the economic, social and cultural development of the region.

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