Deeply Digging in Serious Games for Archaeology

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***Abstract*—Over the years, serious games (SGs) — the games whose main objective is not only entertainment — have become a useful tool for teaching, informing, and drawing awareness to significant research topics. A popular application domain is archaeology. Archaeology raises interest in its core activities involving the application of methodologies like excavations and the production of interpretations, which are crucial in reconstructing the culture of ancient civilizations. In the interpretive process, connections with anthropological and historical theories are essential, ensuring the accuracy and authenticity of hypotheses. Archaeological topics can be addressed in the diverse components of serious game architecture: game mechanics, feedback, challenges, narrative, and game setting, with similarities and differences between approaches in similar situations, giving rise to myriad solutions to engage players with archaeological findings and practices. Through a comprehensive analysis of the mapping between archaeological features and game components, the paper contributes to providing insightful information for game design and game studies. In particular, it addresses how space and time are treated in serious games for archaeology and the different roles assumed by the players while engaged in them.**

***Index Terms*—Serious Games, Gaming, Videogames, Archaeology, Cultural Heritage**

I. Serious Games and Cultural Heritage

Serious games (SGs) are digital games designed to achieve goals other than entertainment [1], such as education, behavior change, or informational purposes. Serious games, with their "learning by doing" paradigm [2] and high player engagement, are effective communication tools in various fields. Such games are used in medicine for rehabilitation, in learning specific techniques or use of machinery, and in cultural scenarios to raise awareness, promote tourism, and educate players [3].

SGs incorporate "implicit" objectives such as education and training into their core elements[1]: settings, narratives, mechanics, challenges, interaction devices, and feedback mechanisms, all tailored during the design phase to align with these goals. Settings can range from virtual labs to historical battlefields, while narratives might involve guiding players through various scenarios like medical emergencies or space exploration. Mechanics could include data analysis in crime-solving games or resource management in environmental simulations. Challenges could involve diagnosing diseases, making ethical decisions, or strategizing in diplomatic scenarios. Interaction devices vary from smartphones to VR headsets, influencing the user experience, while feedback mechanisms provide tangible insights into player decisions.

Serious games are effective in communicating cultural heritage, enabling creators to share and players to engage with cultural values and information (fig. 1). Players can comment on content and how creators present it at any time, from anywhere. This feedback loop enhances the game's educational goals and ensures messages are tailored to audience needs. The process involves thorough documentation of cultural heritage, defining communication objectives, and understanding the audience to customize the message appropriately.

In recent years, several serious games have emerged that focus on archaeology findings (such as sites and artifacts) and methodologies (such as interpretations and excavations). We're not talking about *Indiana Jones* or *Tomb Raider*'s pseudo-archaeology [5], but about commercial and non-commercial games that aim to combine learning and entertainment. For instance, Ubisoft's latest *Assassin's Creed* chapters feature educational modes[2] that allow players to explore historical settings such as Ancient Egypt, Greece, and Viking Age Europe in a non-competitive environment. These games, created by archaeologists and history specialists, allow participants to investigate authentic reconstructions, learn about past daily life and significant events, and ultimately promote tourism [5].

This paper seeks to conduct an analysis of the field of serious gaming for archaeology using a large body of scientific literature. The work focuses on the representation of some fundamental aspects of archaeology in serious games, such as spatiotemporal conception and the audience's (players) role. This article discusses games with the primary goal of disseminating cultural heritage as well as games that focus on methodologies for training and engaging audiences in archaeology.

II. Archaeology and its Cornerstones

Archaeology, fundamentally intertwined with the dimensions of time and space, investigates past societies through material culture and contextual analysis. Temporal analysis, vital for sequencing historical events and cultural evolutions, employs both absolute and relative dating methods, allowing archaeologists to position artifacts and sites within a historical framework, thereby facilitating a deeper understanding

[1]These elements are rearranged from the ones described by Wattanasoontorn et al. [4]

[2]https://www.ubisoft.com/en-gb/game/assassins-creed/discovery-tour

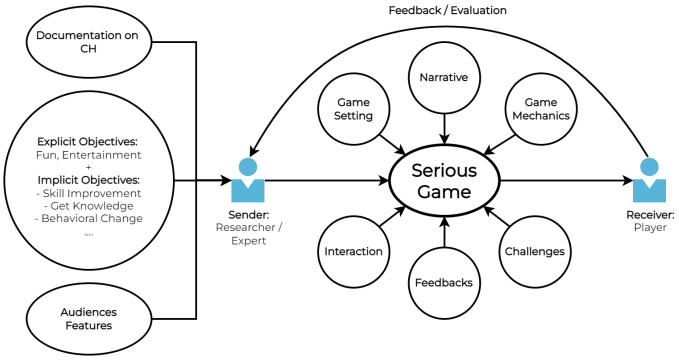

Fig. 1. Serious games and CH Communication

of past human activities and technological progressions [6] [7]. Spatial analysis, conversely, investigates the distribution and geographic spread of archaeological finds, elucidating patterns of settlement, resource use, and social interactions. This analysis sheds light on how past societies interacted with their environments and structured their communities [6] [7].

Archaeology examines the dynamic relationships between human populations, their environments, and cultural practices in a variety of temporal and spatial contexts. Time-geography examines resource allocation, decision-making, and activity patterns to reconstruct past landscapes and understand the mobility and dynamics of human societies [7].

Despite its centrality, the application of time-space relations in archaeology faces critique, particularly regarding the field's historical emphasis on spatial over temporal analysis. Critics argue for a balanced integration of both dimensions to more effectively reconstruct and understand past societies [6] [8]. The dimensions of time and space are pivotal also in archaeological methodology, from excavation to the dissemination of findings, underpinning the interpretive processes crucial for understanding past human behaviors, beliefs, and cultural practices within their specific contexts [9] [10].

III. Mapping Archaeological Features on SGs

Archaeology's spatial analysis—examining artifact locations and site excavations—resembles many games' exploration features. Serious games let players explore virtual archaeological sites, improving their historical and spatial knowledge [11]. Similarly, the temporal focus on continuity and change across epochs matches serious games' narrative structures, which often span multiple eras and provide a chronological view of history. These simulations allow players to track the evolution of civilizations, technologies, and environments [12].

Serious games may use excavation and artifact analysis as gameplay mechanics. The player can play as an archaeologist or learn about archaeologists' interpretations of ancient sites and artifacts. This not only teaches players about archaeological methodology but also promotes critical thinking and deductive reasoning, which are crucial in both archaeology and gaming [5].

This section will then examine the links between these fundamental elements of archaeology and serious game components, focusing on the current state and characteristics of games in this field. This mapping focuses on literature projects from 2014–2024 that explicitly discussed archaeological methodologies or site and artifact dissemination. According to Mortara et al. [3], these projects are artistic/archaeological heritage awareness games. These games teach history, archaeology, and art by letting players interact with a society's artifacts.

A. The Different Uses of Space

1) Spatial Reconstruction: Natural disasters, human activity, and neglect have all caused the destruction or alteration of archaeological sites. Remote or dangerous archaeological sites may be located underwater or in conflict zones. Some sites are under threat of collapse or contain fragile relics, making entry impossible. These reasons support spatial reconstruction and its use in serious games. These reconstructions are typically created using photogrammetry, which allows 3D models to be generated from point clouds created by photographs or laser scans. In addition to photogrammetry, 3D modeling based on interpretive studies is frequently used to complete assets [13]. Most games depict archaeological sites and artifacts as they were discovered, so they contain sections and fragments that are no longer visible or accessible.

Space is used in many serious games for archaeology to recreate historical sites and artifacts, allowing players to explore ancient worlds in an immersive and educational way. For example, *A Night in the Forum* [14] presents a virtual reconstruction of the Augustus Forum as a game setting (fig. 2a). These spatial reconstructions provide context for the narrative and gameplay while also connecting players to the past. Using its spatial aspect, the game encourages players to interact with and learn from their surroundings.

The game's setting gives the player a wealth of information through the intricate details of models and textures. Environmental storytelling [15] involves using environmental details to enhance the game's main narrative. This technique fosters a strong connection to the game by reflecting the player's interpretation and personalizing the experience. It guides players' exploration and decision-making, with environmental cues subtly navigating their path through the story [15]. For instance, in *A Night in the Forum*, players complete various missions within Augustus' Forum, exploring areas such as the temple interior, archives, and tribunals, and encountering the Genius Augusti Statue. Strategically placed torches that ignite as players approach indicate interactive areas, implying paths to continue the gameplay and narrative.

The spatial reconstruction is also the most common choice for virtual explorations that are technically not games because they lack some of the components described in Section 1, but take a playful approach to allowing users to explore archaeological sites and artifacts. *The Virtual Bat Cave* [16] aims to study, conserve, and enhance the Grotta dei Pipistrelli within the Pantalica Nature Reserve (Italy) through

(a) (b)

Fig. 2. (a) *A Night in the Forum* (b) *The Virtual Bat Cave*

3D digitization and virtual fruition. The virtual tour, which only has a torch for illumination, recreates the cave's natural darkness while providing historical narration (fig. 2b). The journey culminates in the bat-populated *Sala del Guano*, which heightens immersion through visual and auditory encounters with bats. Typically, these projects focus on the accuracy and authenticity of spatial reconstructions to ensure a complete experience of extreme environments, such as a cave, for all user categories while limiting the actions that can be performed during the simulation.

2) Space as Game Mechanic, Reward and Challenge: Spatial reconstructions can be part of the game mechanics, rewards, and challenges offered in the experience. The game *In Ersilia's Footsteps* [17] requires players to explore and collect clues in the bathrooms of the 4th-Century CE Villa Romana del Casale in Sicily to complete the main mission. Space challenges can also involve the player's orientation in space or memorizing game environment elements to better retain the reproduced spatial structure. This paradigm is related to a classical treasure hunt, which is very exploited in this field. An example is *The Carthago Nova Game* [18], in which players engage in a series of tasks within the VR environment of the Roman Theatre of Cartagena (Spain), such as locating and collecting artifacts to prevent historical alteration.

Maps and GIS (Geographic Information System) are important components of archaeology that are also replicated in games and used as mechanics. Archaeologists can use GIS technology to explore spatial relationships of archaeological sites, analyze landscape features, and make informed decisions about excavation strategies and site preservation [7]. This is exploited in *Mi Rasna* [19], a real-time strategy and simulation game based on a 2D strategic map. Players manage the development of twelve Etruscan cities, facing economic, agricultural, and social challenges. In *The Seafarers* [20], players can manage a Mediterranean cargo ship as a merchant captain using an innovative map. The game involves navigation, exploration, and trading in order to maximize wealth and teach players about traditional Mediterranean maritime trade.

In other games, space can be considered a reward, motivating players to explore further and engage more deeply with the content. For instance, unlocking new, historically accurate environments to explore after completing certain challenges can serve as a powerful incentive. This happens in *ArkaeVision VR Game* [21], where the player explores, little by little, following the story line and completing objectives, the temple of Hera in Paestum, Italy.

3) Virtual Space to Emphasize Real Space: Space in serious games for archaeology is closely related to the implicit purposes of enhancing real spaces and encouraging tourism by enriching them with additional multimedia experiences and information. This applies to spatial or location-based games that can only be played on an archaeological site or museum [22]. The treasure hunt paradigm is effective for this goal, as it guides players back to their chosen tour route, allowing them to observe both real and virtual artifacts [22].

These games employ the augmented reality (AR) interaction system extensively through smartphone and tablet apps, such as the game presented in the National Museum of Roman Art (Mérida, Spain) [23] that was designed to be a treasure hunt that requires participants to move throughout the museum. It seeks to substitute a number of group activities for the guides' customary explanations, the completion of which will enable a more in-depth comprehension of the displays.

Kleftodimos et al. [24] showed the potential for cultural heritage education of location-based AR through a game at the Dispilio (Greece) archaeological site. In the game, users follow a designated path where they scan QR codes at various points of interest. Each code reveals detailed reconstructions of ancient structures and objects, along with comprehensive explanations about the site's historical and cultural significance.

Although not in a game, Cisternino et al. tested the use of mixed reality technology at outdoor archaeological sites [25]. Their research led to the development of an AR and AV (augmented virtuality) app model that utilizes 'virtual portals" as a novel method to transition users between the real world (present) and virtual reconstructions of historical sites (past), enhancing their understanding of spatial and temporal dimensions. The use of this approach as a future game element could be a novelty in the field.

B. The Different Uses of Time

1) Time as a Narrative Tool: In most serious games for archaeology, time serves as a narrative tool, enabling players to travel through different historical periods and witness the evolution of civilizations, technologies, and sites. For instance, the serious game *Father and Son* [26] explores the collections of the National Archaeological Museum of Naples through a narrative journey across time. The game leverages the museum's artifacts as a narrative device, allowing players to experience different historical periods and stories. This temporal exploration bridges the gap between past and present, inviting players to discover the museum's findings through the eyes of the protagonist. Even the already mentioned *A Night in the Forum* incorporates a temporal narrative journey inside the Augustus Forum as players find themselves locked in after hours, discovering a helmet that transports them back in time. Finally, in the *Living Hill Project* [27], about a Carolingian Age village in Poggibonsi (Siena, Italy), players must return three objects collected by

a girl visiting their grandfather during the 1910s to their rightful owners in one of three past periods. These temporal journeys enrich the player's experience, providing a dynamic way to interact with history.

2) Time as a Game Mechanic: Time, just like space, may not only be a narrative device but also assume the main role as a game mechanic. This is the case in serious games in which the transition between one historical period and another is essential for the completion of the game, since through this "view of the past", players can obtain information useful for the continuation of the main quest. Most serious games for archaeology feature a timeline, which is essential for displaying events chronologically. The timeline lets players explore and compare different environments and elements across historical periods. An example is *Roots in Greek History* [28], in which players can use an interactive timeline to explore Greek history and understand significant events, including visits to famous cities and places. The user can choose and explore specific time points and search for historical events and cities using lexicographical or chronological criteria. Another example is the *BeA-ViR System* [29], which enables users to explore Japanese archaeological sites and artifacts using a timeline. By selecting a historical period, users can view only sites that were active during that period.

C. Players and Roleplaying

1) Players and archaeology methodology: In serious games for archaeology, players take on various roles that are frequently related to both implicit goals and narrative choices. In fact, many projects seek to communicate, educate, and inform about archaeological methodologies. In these games, users assume the role of archaeologists carrying out their tasks, such as digging soil to reveal an ancient site, diving to recover ancient artifacts at the sea's bottom, or detecting and monitoring an area's physical characteristics (remote sensing practice).

In *RelicVR* [30], players use shovels or hammers to dig up valuable artifacts in a mound of earth, highlighting the precision and skills needed by archaeologists. *IRelics* [31] simulates the digging process using a tangible interface, unlike *RelicVR*, using brushes, sprays, and other tools on a monitor equipped for such treatments (fig. 3a). Georgiadi et al.'s example [32] is useful for teaching elementary school students about archaeology. The game involves finding and collecting artifacts in designated areas, then using them to unlock educational mini-games and activities on a tablet. Finally, a virtual reality archaeology platform from the University of Illinois teaches students practical skills without field visits, benefiting those with financial or access constraints [33].

Underwater Cultural Heritage (UCH) has specific practices for immersion, excavation, and documentation of findings. In this context, important works such as the *Diving Simulator* by Plecher et al. [34] are essential in recreating the same underwater experience (related to swimming and breathing) and teaching archaeological methodology (fig. 3b).

(a) (b)

Fig. 3. (a) *IRelics* (b) *Diving Simulator*

A relevant example is the game *Yrsum 3D* [35] that combines two-dimensional and three-dimensional elements derived from typological reconstruction. This game aims to demonstrate the application of remote sensing data in the field of edutainment, in which players can interact with 3D objects, assembling and disassembling them to reconstruct a medieval village located in southern Italy.

2) Players as part of the archaeological interpretation: Serious games are a practical tool for archaeological dissemination, and the role of players in most games that aim to enhance archaeological sites, museums, or artifacts is that of appreciators of archaeological interpretations, resulting from collaboration with experts in history, sociology, and anthropology. Users of these games may not take on a specific role but instead complete the game objectives and observe the experts' reconstructions and textual/verbal information, depending on the narrative. In the game *Hold the Hut* [36], a prehistoric hut discovered in Potenza, Italy, is enhanced with mini-games and explanations of its use. Such a hut is shown to the user as a reconstruction of how it should have appeared in its original form. Many virtual exploration projects, such as Pleito Cave [37] in California or Fuente Nueva 3 in Orce, Spain [38], involve subjects passively observing reconstructions and information, similar to a spectator experience.

Instead, in narrative-driven games, players can play historical characters who take sides in the plot. Pujol and Champion [39] describe how this increases cultural awareness and engagement. Being culturally present entails becoming physically, mentally, and emotionally immersed in a simulation in order to comprehend and appreciate a community's heritage beliefs and practices. This occurs when game mechanics and storytelling are based on the archaeological cultural asset's historical events and practices. For example, Jonathan Barbara [40] discusses the VR experience of the Hypogeum of Hal-Saflieni in Malta. This project proposes documented (based on first-hand sources), speculative (based on interpretation), and repurposed (from other games) game mechanics to improve the Maltese hypogeum and engage people as much as possible, including them in the archaeological research process and the site's ancient uses.

IV. Discussion

This study underscores the natural alignment between archaeology and serious games (SGs), highlighting how the

foundational elements of archaeology—spatial and temporal analysis—are leveraged to create immersive educational experiences. By incorporating these elements into SGs, players engage more deeply, navigating through time and space to explore historical narratives and archaeological methods. This not only enhances the gameplay but also serves as an educational tool, inviting players to actively participate in the discovery process. Through such engagement, SGs aim to foster a deeper appreciation and understanding of our cultural and historical heritage, making the audience active participants in a journey of exploration and preservation.

Among the presented works, games concerning tangible cultural heritage explicitly considered by the authors as artifacts or archaeological sites were mainly included. This has led to the exclusion of some games that are more focused on intangible aspects, such as those for raising awareness of folklore, languages, dances, or reconstruction of historical events such as important battles [3]. The latter are manifestations of cultures (thus relatable to archaeological study), but do not contain explicit elements of material culture at the core of their implicit goals.

Despite the strong links between the games presented in this paper and archaeology, some aspects of spatiotemporality relevant to archaeological studies are still missing from today's serious game landscape. For example, it may be interesting to learn about the subdivision of human activities in the past. The study of food and meals during daylight, as described by Hamilakis for the Aegean prehistoric period [41], could make a significant contribution. According to Hamilakis, the temporal ordering of events, the duration of feasting events, and the rhythm of consumption all help to create a mnemonic record that reflects social memory and identity. Similarly, games could use the concept of time to simulate how seasonal changes affect ancient communities, such as agricultural cycles, festivals, and resource management. In archaeology, this could mean researching seasonal occupation patterns and their impact on ancient societies.

Space, in turn, could be used to depict social interactions and communal life in ancient civilizations. In archaeology, this could mean analyzing the layout of ancient settlements to better understand community hierarchy and social interactions. This aspect is suitable for strategy games, such as *Mi Rasna*, but with a finer granularity on settlement management and space division. Commercial games like *Civilization* and *Age of Empires* use seasonality and space division concepts, but they prioritize entertainment over historical and archaeological aspects, which are often only used as settings [42].

Regarding the audience's role, it is important to note the presence of only a few games that simulate the excavation experience. According to Hagen's Master Thesis [43], the application developed by the University of Illinois [33] stands out as one of the few VR platforms focused on teaching archaeological excavation, while other similar applications emphasize historical site exploration and ignore educational features. Furthermore, unlike the application Hagen proposed in his thesis, the current applications, including the aforementioned *IRelics* and *RelicVR*, do not support multiplayer or portability. Multiplayer is an important feature in archaeology education because it allows experts with various roles and backgrounds to participate in investigations. Archaeological excavations require collaboration [43].

Finally, the presented games highlight the need to increase audience engagement in the interpretation process. According to Rahaman et al. [44], including users in the interpretation process enhances their experience and understanding of cultural heritage. By encouraging dialogue and collaboration, these initiatives can gather diverse perspectives, resulting in a more inclusive and comprehensive portrayal of heritage. Treating the audience as co-creators can foster deeper engagement and a more holistic appreciation of heritage. This process allows for the enhancement of cultural assets in ways that are close to possible, different community visions, rather than prioritizing only those of experts [45].

V. Conclusions and Future Directions

The study shows that serious games and archaeology can be used together to make historical and cultural heritage more engaging and educational. The analysis shows that SGs are unique platforms for simulating archaeological practices and immersing players in temporal and spatial narratives that deepen their understanding of past civilizations.

Despite the promising developments, there are still areas within SGs that require additional innovation and research. The integration of other time and space-related aspects, such as seasonal changes, daytime hours subdivision, and a more detailed representation of settlement structure and organization. Furthermore, there is a significant disparity in the representation of collaborative and multiplayer aspects in archaeology games, which are critical for reflecting the true nature of excavations and fostering a communal learning environment.

Future efforts should concentrate on developing SGs that allow for active participation and collaboration among players, foster a stronger connection with the material, and promote a more nuanced understanding of archaeological methodologies. SGs can become more effective tools for disseminating and educating about archaeological heritage by broadening their scope to include a broader range of cultural and historical aspects, as well as improving interactive and multiplayer functionality.

To summarize, while SGs have demonstrated significant potential in the field of archaeology, much work remains to be done to fully realize their educational and interpretive capabilities. By addressing current limitations and exploring new avenues for incorporating cultural heritage into SGs, researchers and developers can create more immersive, educational, and inclusive experiences that help the public understand and appreciate archaeology and historical heritage.

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