



# 1 Introduction

The representation of human remains in Cultural Heritage (CH) experiences poses significant ethical challenges and complexities for museums and CH organizations. The importance of engaging with human remains responsibly and respectfully is a critical aspect. The display of skeletal remains, mummified bodies, or other human artifacts raises concerns about cultural sensitivity, the rights and dignity of the deceased, and the potential for perpetuating harm. Striking a balance between the educational value of showcasing human remains and the ethical considerations surrounding their display requires thoughtful decision-making and adherence to ethical guidelines. CH professionals and researchers must navigate legal, cultural, and ethical frameworks to ensure that human remains are treated with the utmost respect, mindful of the beliefs and sensitivities of the communities involved. This necessitates a collaborative approach, engaging with anthropologists, archaeologists, as well as experts in ethics to inform the responsible curation and interpretation of human remains in museum exhibitions and CH organizations. (Anastasovitis, Nikolopoulos, et al., 2020)

Recent technological advances have led the gaming industry to a new era where the narration of human biographies through Serious Games (SGs) is more attainable than ever. SGs in general, are games with educational purposes that combine gamification with learning (Landers, 2014) (Khalidi et al., 2023) (Yu, 2019). The SGs ecosystem is a major research field that could be traced back to the work of Plato, who said in his *Republic*: "Don't use force in training the children in the studies, but rather play. In that way you can better discern what each is naturally directed towards". This particular statement can find fertile ground in our century, given the exploitation of advanced technology in the fields of Virtual and Augmented Reality (VR and AR, respectively). Moreover, SGs and mobile applications are examples of educational technologies that have enhanced the academic performance of students and increased their engagement in learning activities (Yu, 2019).

The construction of the Metropolitan Railway in Thessaloniki brought to light relics of the city's Hellenistic, Roman, Byzantine and Ottoman periods as well as more than 4500 human burials. Through the need of presenting these findings to the general public, the concept of *ECHOES* emerged. In the *ECHOES* project, which is in its second of three years of development, the main purpose is to reinforce the knowledge related to the ancient citizens of Thessaloniki city in Greece, through fully immersive and interactive experiences. This will be achieved by creating photorealistic virtual surroundings and game mechanics that will take into serious consideration the criteria that differentiate conventional game experiences from SGs (Caserman et al., 2020). Thus, the focal point of the SG will ensure that the user is always informed about the learning goal of the SG. That indicates that the learning part of the CH experience would be unavoidable, otherwise, the achievement of the learning goal would be compromised.

The scope of this contribution is to present an innovative approach that combines SGs through VR, AR, and Gamification to address the complex challenges surrounding the representation of human remains in CH experiences. By leveraging immersive technologies and gamified learning methods, this study offers a novel framework for ethically dealing with human remains in a sensitive and educational manner. According to Murray (Murray, 2017), the term "immersion" is a metaphor that derives from the actual sensation of being submerged in water. We seek the same sensation from a psychologically immersive experience as we do from a swim in the ocean or a pool: the sense of being enveloped in an entirely different reality that consumes all of our attention and all of our perceptual capacity. By harnessing the power of VR, AR, and gamification, this research offers a valuable contribution to the field, revolutionizing the way human remains are represented and experienced in the context of CH. In Section 2, the interdisciplinary related work from different scientific fields is being presented. In Section 3, the methodology that will be implemented will be described, Section 4 dives into the design and development phase of the project, while Section 5 and Section 6 conclude with a generic discussion and the next steps of the process.

## 2 Related work

The integration of creative industries, and eXtended Reality (XR) technologies creates a dynamic and innovative field of research. By combining these disciplines, researchers can leverage archaeological and anthropological insights to create engaging and immersive experiences (Innocente et al., 2023). This interdisciplinary collaboration fosters a deeper understanding of CH and enables the preservation and dissemination of knowledge in captivating ways (Banfi and Bolognesi, 2021) (Barreau et al., 2020) (Cai et al., 2018). Together, these disciplines and technologies open up new possibilities for transformative research and applications that bridge the past and present.

### 2.1 Archaeology

Thessaloniki city was founded in 315/16 BC by Cassander who named the city after his wife, daughter of Philip II and sister of Alexander the Great. Its strategic position on the maritime and land routes played a decisive role in its future development. Archaeological evidence shows that the city flourished and became an economic and political hub, that attracted people, merchants, and professionals of different geographic and cultural origins (Nigdelis, 2010) (Vitti, 1996). To draw the historical context of the biographies developed in the context of *ECHOES*, the archaeological findings that have been excavated during the construction of the city's metropolitan subway have been studied (Lambrothanassi et al., 2018). By incorporating the latest archaeological evidence and with the use of databases and GIS, we document, save, and diffuse this invaluable wealth of CH in order to illuminate the city's historical transitions.

### 2.2 Anthropology

In the context of *ECHOES*, we incorporated a variety of conceptual toolboxes to reconstruct life in ancient Thessaloniki, based on the archaeological skeletal material that have been excavated during the construction of the metropolitan subway. We use geometric morphometrics analysis of the temporal bone (Harvati and Weaver, 2006) to trace secular changes of the population and population genomics analyses (PCA, ADMIXTURE, f- statistics) to investigate the genetic intra- and inter- population differences (Antonio et al., 2019). Furthermore, a multi-tissue isotopic approach was employed to reconstruct the infant and adult diets and examine the intra-site differences between historical periods, sex, and cultural contexts (Walter et al., 2020). We use skeletal measures such as linear enamel hypoplasia (Nakayama, 2016), stature (Koukli et al., 2023), and trauma (Krakowka, 2017), as biological indices for assessing the living standards of the past (Steckel, 2008).

### 2.3 Creative Industries in Cultural Heritage (SGs, VR, AR)

The preservation of CH is only feasible within the context of cultural institutions, heritage sites, and archives. In recent years, there has been a serious attempt to involve the learners in this process. This was a precursor to the creation of Virtual Museums (VMs) and the procedure of transforming the learning environments into a digital form (Anastasovitis, Ververidis, et al., 2017) (Anastasovitis and Roumeliotis, 2023) (Doukianou et al., 2020). The target audience could vary from young children to adults who are interested in the main theme of the SG. In *ECHOES*, the learners are children above the age of 7 years old, which is the minimum age limitation for VR gaming, and adults of all ages who are interested in the history of ancient Thessaloniki. Apart from VMs, the utilization of novel technologies like VR and AR to design a new environment for the users to reinforce gamification seems to be the key factor for them to increase engagement, explore, play, and finally, learn (Huynh et al., 2016). Furthermore, the virtual or augmented projection of cultural assets that have been destroyed or decayed, in the same place that their physical form once existed, has more meaning for users than experiencing the same projection within the confines of a museum (Dumiak, 2018). Thus, there is a tendency to implement those technologies in cultural guide tours as well.

Regarding the learning methods in SGs, storytelling is the most common approach that SGs have adopted. Commonly, narration in cultural assets focuses on the description of the assets' traits, not on revealing their multi-layered meanings and aspects, and not on the emotions and morals, which are the main motivations of people (Blasi, 1999). VR in CH is frequently integrated with narration to optimize the effects of both VR and storytelling. In this scenario (Corallo et al., 2019), the player uses different senses to get information while experiencing the location where the tale is unfolding in the virtual world. For example, *iMareCulture* investigated how storytelling, VR games, and underwater archaeology could be merged such that players may visit long-lost towns beneath the sea (while playing in VR). Zhou et al., 2018 proposed a learning model in virtual environments that combines pedagogical aspects and human-computer interactions. This model has constructivism's principles as its core, which is a process relying on the autonomy of the students and self-awareness (Pande and Bharathi, 2020). Thus, the students can operate in a safe environment and learn while making mistakes in a novel and autonomous way.

### 3 Methodology

The proposed methodology in order to highlight the human past of the city of Thessaloniki through a key factor of social expression: the biographies of its inhabitants, is divided into four steps. First, a questionnaire was distributed to define the preferences of the users, and then the game scenarios and the reward system were defined. The third step is the production phase of the AR and VR experiences, while the last step in the methodology is the user experience and gained knowledge evaluation. The whole methodology was developed through the prism of the SGs, while the pedagogical approach was the focal point.

#### 3.1 Questionnaire

In the preliminary phase of the project, in order to define the user needs and preferences regarding VR and AR technologies, a questionnaire was distributed to three main groups of people: (1) *Citizens of Thessaloniki (188 answers)*, (2) *Tourists of Thessaloniki (103 answers)*, and (3) *Educators (98 answers)*. The questionnaire contained several generic questions regarding the level of familiarization of the respondents with the aforementioned technologies. It also contained questions about the VR and AR environments and the information that will be communicated within the SG. While analyzing the results, it was observed that the vast majority of the respondents (80.9%) were not familiar with and had not used VR technologies. This is mostly related to the fact that they did not have the opportunity to do so. However, the most encouraging fact is that they are willing to attempt to familiarize themselves with them and that they are interested in SGs for CH. Regarding AR, 46.8% of the respondents are already familiar with the concept, but 67% have not used this technology before. Considering the amount of time that they are willing to spend on those experiences, it occurred that 15 minutes on average is the ideal time for both VR and AR experiences.

#### 3.2 Game Scenarios and reward system

Before the production phase, it was of major importance to develop the scenarios and the reward system of the SG. In this section, the game scenarios are presented, which allow players to explore the cultural artifacts and historical landmarks that were excavated. These scenarios blend seamlessly with the underlying reward system, which strategically incentivizes players to delve deeper into the CH experience. By striking a harmonious balance between educational content and engaging gameplay mechanics, our research aims to provide experiences that both educate and entertain, fostering a deeper appreciation for CH in the digital era.

##### 3.2.1 AR environments

The primary purpose of the AR environment is to offer users a unique perspective and experience of the city. The AR application will begin by presenting a map of the historical center, providing users with an overview

of the available points of interest. This initial screen serves as a gateway for users to navigate and choose their preferred locations for AR exploration. Once a location is selected, the AR environment is presented to the user, augmenting the user's surroundings with 3D cultural assets that once existed in that specific place. The users will have the opportunity to move around the assets in the AR space, reading relative information through pop-ups on their screen, while listening to historical information regarding the specific asset through audio recordings. Alongside the augmented projection, users are provided with relevant historical information about each asset, offering insights into its significance and context.

To further enrich the user experience, the AR application will be related to guided tours along three different routes within the historical center. These tours provide curated paths and narratives, guiding users through key points of interest and showcasing different aspects of ancient citizens' lives. Through interactive elements and informative content, users can delve deeper into the city's history. This interactive component invites users to engage with virtual elements, enabling them to explore different facets of daily life, such as occupations, social activities, and cultural practices. Users will then have the opportunity to gain a deeper understanding of the ancient city's dynamics and societal structures. In essence, the AR environment aims to provide users with an engaging, informative, and interactive tour of the historical center.

### 3.2.2 VR environments

Subsequently, the VR application will be divided into six unique environments. In the first virtual environment, the users will be witnessing the internal part of Thessaloniki's metropolitan subway, while this is the place in which the characterizing goal of the game will be presented to them. The subway was chosen because this is the place where the archaeological excavations which led to this project took place. Then, on the inside of a wagon from the subway, the first acquaintance with the ancient citizens of the city will be achieved. The subway passengers will initially appear as blurred forms, with the goal being to learn about their stories and unblur their forms as a reward. The six passengers will introduce to the player their own VR environment related to their biography.

A particularly intriguing VR environment is the tomb chamber. This environment would be created using the architectural designs provided by the archaeologists and would serve as the focal point for the storytelling of two main thematic axes: (1) the reuse of graves, and (2) the ancient burial practices. As is observed from Fig. 1, the storytelling will be divided into five areas within the environment. First, the users will be placed at the entrance of the structure, and some generic information will be presented to them. As the player moves and explores further, the facts about the past will become more specific and targeted.

Additionally, before the closure of the narration related to each virtual experience, a reward in the form of information will be presented to the player. When the characterizing learning goal is achieved, the users will be rewarded with the phenotypic characteristics of the ancient citizen of the city who had virtually transported them to the specific environment. As a result, the player will be informed about the ancient citizen's eye, hair, and skin color, as well as other anthropological findings. Then, the players will be transferred back to the subway wagon to choose a different passenger/environment. The aforementioned reward system, will be implemented in all the VR environments:

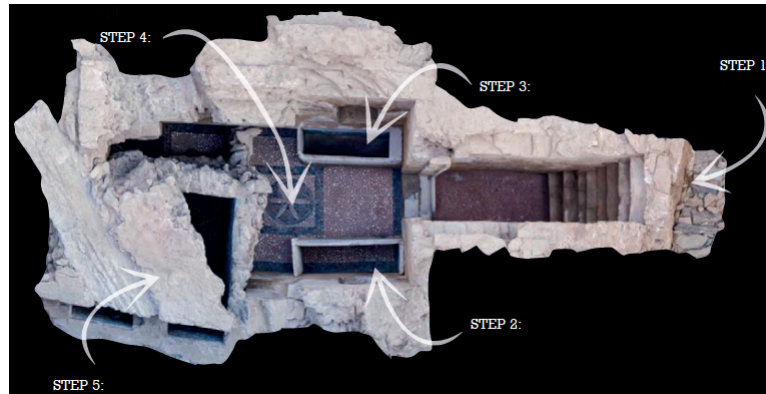
1. *The subway wagon.*
2. *The tomb chamber.*
3. *A port (3rd c. BC).*
4. *The scribe's office (1st-2nd c. AC).*
5. *The interior of a child's room (2nd c. AC).*
6. *A Byzantine triclinium<sup>1</sup>.*

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<sup>1</sup>Triclinium: the dining room of a Byzantine house

Those environments will be developed from scratch under the prism of the archaeological references to acquire a visualization of how they would have been in the past. By adhering to archaeological references and incorporating them into the design process, the aim is to create depictions of the past that will try to resemble those places. Through this approach, the contribution to the preservation and appreciation of CH is feasible, offering users a glimpse into history. Lastly, the only thing that the two experiences (AR and VR) have in common is the main theme of the inhabitants of ancient Thessaloniki, and the user can play them separately.

**Figure 1.** The level of information in the tomb chamber VR environment.



### 3.2.3 User experience and gained knowledge evaluation

The final part of the proposed methodology is highly related to the users. According to researchers, the most popular methods for documenting prior knowledge and what was learned during the game session are undoubtedly pre- and post-game questionnaires and interviews (Catalano et al., 2014). Thus, in the demo sessions, assessment methodologies will be employed to measure the quality of user interactions (in terms of efficiency, navigation, orientation etc) and the knowledge acquisition process. That means the users' prior knowledge will be captured, and it will be correlated to the post-game gained knowledge, while user feedback mechanisms, such as surveys and interviews, will capture subjective experiences and gather insights for improvement. Furthermore, to evaluate the user interfaces, the technologies that were utilized, and the general experience of the users, an additional questionnaire would be distributed. The questionnaires will contain, among other things, several questions regarding the level of perceived enjoyment of the users, their reflective thinking, their perceived learning, and their level of satisfaction. Additionally, quantitative evaluation techniques will be deployed, including pre- and post-experience knowledge assessments, to measure the effectiveness of the experiences in imparting cultural understanding and historical knowledge. By examining user feedback and evaluating gained knowledge, the aim was to refine and optimize the immersive experiences, ensuring that they offer an engaging, educational, and transformative journey through CH.

## 4 Design and development

In this section, the design considerations and development methodologies that shaped the final VR and AR experiences are explored. First, the paper focuses on how the concept design led to the final scenarios. Afterwards, the selection of appropriate technologies and tools is explained, as well as the creation of realistic 3D models and textures, and the integration of historical data. At last, the focus is on the implementation of user interfaces, and elements that enhance user engagement and facilitate exploration through gamification.

## 4.1 From concept design to Scenarios

The first thing before the development phase was to develop the process of transforming the initial concept into written scenarios. The primary objective is to bring the history and CH of Thessaloniki to life through immersive storytelling and interactive experiences. The first step in this process involves thorough research and consultation with anthropologists, archaeologists, and experts in the field of CH. By examining historical records, archaeo-anthropological findings, and architectural designs, a deep understanding was gained, related to the specific periods that were portrayed. Using this knowledge as a foundation, we proceed to the design of the scenarios that will be featured in the VR application. Thus, the above-mentioned distinct scenarios that represent different aspects of Thessaloniki's history and cultural significance were carefully selected.

In the first scenario, the user explores the 3rd-century BC port of Thessaloniki, highlighting its role as a vibrant trade center and its multicultural character. This scenario aims to convey the city's significance as a hub of commerce and cultural exchange. Moving forward in time, the second scenario brings the player to a scribe's office, inspired by an excavated tomb from the 1st to 2nd century AD. Here, the narration focuses on the professions and occupations that were prevalent during Roman Thessaloniki, shedding light on the diverse livelihoods and activities of its inhabitants. The third scenario offers a glimpse into the interior of a child's room, set in the 2nd century AD. This scenario focuses on the theme of breastfeeding and childhood in Roman Thessaloniki, providing insights into the nurturing and upbringing practices of the time. Lastly, the player explores the Byzantine period through a 3D reconstruction of a Byzantine triclinium, the dining room of a Byzantine house. This scenario revolves around food preferences and nutrition during the Byzantine era, offering users an immersive experience of dining customs and culinary traditions.

Throughout the design process, the integration of gamification elements, such as gradually revealing information and providing rewards, further enhances user engagement and knowledge acquisition. By combining historical research, creative design, and immersive storytelling, the aim was to create a compelling and educational experience that brings Thessaloniki's history and rich CH to life for users.

## 4.2 Technologies

The next step in the methodology is the creation of the AR and VR environments. For this process, four key objectives were taken into account to design the SG: (1) *Interaction within the SG*, (2) *Immersion level*, (3) *User participation*, and (4) *Photorealism of the environment*. Moreover, this section describes the cutting-edge technologies and tools that were employed to achieve these objectives and create the CH experiences. Thus, the advancements in AR and VR hardware are explored, as well as software development frameworks, and content creation pipelines that enable us to create highly interactive and immersive environments. By leveraging these technologies, the focal point was to engage the users and enhance the sense of presence through the different environments.

### 4.2.1 Virtual Reality

To achieve the aforementioned goals, *Unity 3D*<sup>2</sup> was selected as the primary tool for designing VR environments. This cross-platform game engine allows us to create immersive scenes comprised of various objects, known as GameObjects. These objects interact with one another, the environment, and the player through C# programming language scripts. By utilizing *Unity*, realistic interactions are programmed, ensuring a seamless and engaging experience for the user. To enhance the immersion level, the focal point was to create photorealistic scenes within the VR environments. By leveraging *Unity's* capabilities, virtual environments that closely resemble real-world settings can be developed. The attention to detail in creating these scenes adds depth and authenticity to the virtual experience, further immersing the user in the chosen biographer's personal

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<sup>2</sup><https://unity.com/>

story.

Within these VR environments, users will have the opportunity to interact with 3D objects directly related to the chosen biographer and his personal journey. Users can also interact, hold and rotate the objects in their (virtual) hands. The VR environments serve as a gateway to transport users to different locations, allowing them to explore and engage with historically significant places tied to each biographer's story. Archaeological findings discovered within the graves, such as vessels, figurines, and jewelry, as well as the archaeological findings on human remains, play a crucial role in shaping the story. These artifacts hold valuable information about the communities, individuals, and social dynamics of the period. To recreate these findings in the digital realm, advanced 3D modeling tools like *Cinema 4D*<sup>3</sup> are employed. This allows us to depict decayed artifacts with a high resemblance to the originals, bringing their historical significance to life. In cases where intact preserved objects exist, the photogrammetry technique is utilized to digitally recreate them, preserving their original form and appearance.

At last, users can examine and extract desired information from the digitalized objects through pop-up texts and audio recordings, gaining insights into the cultural, social, and historical context surrounding them. By leveraging the capabilities of *Unity*, *Cinema 4D*, and photogrammetry, a high level of fidelity in recreating these objects is ensured, providing users with an immersive and educational experience within the VR environments.

#### 4.2.2 Augmented Reality

For the AR application targeting *Android* devices, the powerful combination of the *Unity* game engine and *ARCore*<sup>4</sup> is leveraged. *Unity* provides a robust development environment with extensive tools and resources for creating immersive AR experiences. *ARCore*, Google's AR platform, enables advanced tracking, environmental understanding, and motion tracking capabilities, allowing users to seamlessly interact with virtual content within the real-world environment. On the other hand, for *iOS* devices, the capabilities of *ARKit*<sup>5</sup> are harnessed. This *Apple*'s AR framework, along with the *Unity* game engine will provide the combination for the development. *ARKit* provides a comprehensive set of tools and features for creating high-quality AR experiences on *iOS* devices. The integration of *ARKit*'s advanced tracking and scene-understanding capabilities with *Unity*'s extensive development capabilities and cross-platform compatibility will lead to the desired outcome. To facilitate the placement of 3D models in various locations within the AR experience, *Microsoft*'s *Azure Spatial Anchors*<sup>6</sup> will be utilized. This powerful software solution allows the storage of a vast array of points of interest on a server and the selection of the exact position to project the 3D models in real-time. By utilizing *Azure Spatial Anchors*, virtual objects are dynamically positioned within the AR environment, ensuring precise alignment with physical locations in the historical center of Thessaloniki.

These technological choices, *Unity* game engine, *ARCore*, *ARKit*, and *Azure Spatial Anchors*, provide the necessary tools to create a highly interactive and immersive AR tour of Thessaloniki's historical center. Leveraging the user-friendly interfaces provided by these technologies, AR experiences would be offered to the players, allowing them to seamlessly explore historical landmarks, discover points of interest, interact with 3D models, and augment them in the real-world environment.

### 4.3 Gamification

Apart from the educational character that the experiences focus on, it is crucial to discuss the concept of gamification that was integrated into the efforts of the project. By infusing interactive elements and gamified

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<sup>3</sup><https://www.maxon.net/en/cinema-4d>

<sup>4</sup><https://developers.google.com/ar>

<sup>5</sup><https://developer.apple.com/augmented-reality/ARKit/>

<sup>6</sup><https://azure.microsoft.com/en-us/products/spatial-anchors>



features into the AR and VR experiences, the focal point is to enhance user engagement, motivation, and enjoyment. Gamification techniques, such as points, achievements, and quests, are strategically integrated to incentivize exploration and knowledge acquisition (Sailer et al., 2013). These game mechanics create a sense of progression and challenge, driving users to delve deeper into CH content. Furthermore, the concept of meaningful rewards within the game context is explored, offering users a sense of accomplishment and reinforcing their connection to the CH narration. Through this approach, the aim is to foster a deeper and more interactive relationship between users and CH, making the learning experience immersive, enjoyable, and impactful. Gamification, in essence, transforms the CH experience from a passive observation to an active and participatory journey. Introducing game mechanics and elements while tapping into intrinsic motivators such as curiosity, mastery, and achievement, eventually makes the exploration of CH content an engaging and rewarding endeavor. The points and achievements system encourages users to uncover hidden artifacts, and complete quests, thereby expanding their knowledge and understanding. Moreover, by visualizing the ancient inhabitants in the form of avatars and incorporating realistic animations into their movement, the user can relate to the ancient citizens and their personal narration. Additionally, the concept of meaningful rewards provides a tangible sense of progress and reinforces users' commitment to the experience. Ultimately, gamification serves as a catalyst in creating an interactive and memorable CH journey that combines education, entertainment, and a sense of accomplishment.

## **4.4 Limitations**

### **4.4.1 Ethical issues regarding the use of human remains**

In countries with archaeological CH, like Greece, human remains of ancient times, mainly skeletons, are commonly found in archaeological excavations, often in rescue excavations conducted on the occasion of infrastructure projects, such as the METRO railway's excavations presented in the paper. Many of these remains are included in museum collections and displays, while others are the subject of research and dissemination activities, as in the case of the ECHOES project.

The management and use of human remains in scientific research has been a subject of long and growing interest among professional bodies, raising issues regarding the proper approach to the remains based on ethical guidelines (Clegg, 2020). In many countries, different rules apply for the treatment of remains from different time periods. Consequently, varying ethical models apply for humans that are recently deceased and whose identity is known, and for humans that come from civilizations that no longer exist and are far removed from the present. Museums often adopt dissemination practices and present or display human remains with the aim of educating people in science and history, explaining burial practices, and bringing people into contact with the past. In this case, specific ethical guidelines are considered in order for the museums to handle the human remains in the most respectful way, regarding both their physical treatment and their interpretation perspective (Culture Media and Sport, 2005)<sup>7</sup>.

As advancements in technology have conquered a place in the field of CH dissemination, allowing people to have a glimpse into the past with the assistance of visualization technologies (Alves-Cardoso and Campanacho, 2022), ethical considerations have reached the research community regarding the reconstruction and virtual rejuvenation of deceased individuals. 3D imaging can produce accurate and realistic models that share many physical traits, although cases such as facial reconstructions have been frequently criticized for causing false perception (Smith and Hirst, 2019).

Taking into account the abovementioned restrictions and ethical considerations regarding the virtual reproduction of human remains, the project's research focused on developing 3D models of humans based only

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<sup>7</sup><https://www.gov.uk/government/publications/guidance-for-the-care-of-human-remains-in-museums>

on the accurate physical traits provided by the anthropological research outcomes. More specifically, the 3D avatars of the ECHOES project will be presented in a hybrid form, not completely reconstructed as human figures but as ghost figures, revealing only part of their physical characteristics such as eye, hair, and skin color.

#### 4.4.2 Software and hardware limitations

At this stage, we faced certain limitations when developing the experiences. Firstly, developing immersive and interactive experiences demands powerful computing resources, which can be costly and may limit accessibility for some users (Hande et al., 2023). Secondly, compatibility issues between different hardware platforms and operating systems can hinder the seamless deployment of VR and AR applications. Additionally, the creation of high-quality 3D models, textures, and animations requires specialized skills and time-intensive efforts. Furthermore, the continuous advancement of immersive technologies necessitates ongoing updates and optimization to ensure compatibility with evolving software and hardware standards (Ledgerwood et al., 2023). Despite these challenges, by addressing these limitations through iterative development and collaboration with technology experts, we can overcome barriers and create applications that combine CH and education.

## 5 Discussion

The 1990s witnessed an initial efflorescence in interest and development of AR and VR technologies, but they faced limitations due to hardware constraints, leading to a decline in their popularity (Kress, 2020). However, in recent years, there has been a resurgence of interest in immersive technologies, fueled by advancements in hardware capabilities and cutting-edge technologies. In the post-COVID period, we find ourselves on the brink of a new era, where XR technologies are integrated with many sectors. This opens up vast possibilities for education, entertainment, and social interaction. Moreover, the term *edutainment* is highly correlated to the potential of the XR technologies. It emphasizes the fusion of education and entertainment, harnessing innovative methodologies to engage and educate users in compelling ways. By leveraging the immersive nature of this digital era, educational experiences can be transformed into interactive journeys, captivate learners and enabling them to actively participate in the learning process.

In this evolving landscape, learners can explore historical sites, interact with virtual artifacts, and engage in simulations that bring abstract concepts to life. The immersive and interactive nature of this allows for a deeper level of engagement and understanding, making the learning process more enjoyable and impactful. As a group of interdisciplinary researchers from various fields, we are excited about the potential of XR technologies to revolutionize education. By embracing this novel concept, we can create educational experiences that transcend traditional boundaries, and fostering a new era of immersive and effective learning.

## 6 Conclusions

Immersive technologies and the creative industry of videogames play a crucial role in addressing the restrictions and ethical issues surrounding the representation of difficult CH, such as human remains. Thus, it is important to approach these representations with care, adhering to ethical guidelines and cultural sensitivities. Through thoughtful design and collaboration, immersive technologies offer opportunities to foster meaningful connections and navigate the complexities of difficult CH.

The goal of this contribution is to outline the approach used to create immersive experiences for the ECHOES project. Even if the project is still in the planning stages, this paper provides a chance to emphasize the values and concepts that shaped its overall strategy. The basic goal of ECHOES is to effectively disseminate the

findings of anthropological and archaeological research through the gamification and visualization of historical information. It soon became apparent that utilizing cutting-edge technologies to show cultural content might increase its interpretive potential and establish effective communication channels, while VR and AR technologies make cultural resources accessible and turn passive storytelling into engaging experiences. To conclude, this methodology could be adopted by researchers who are searching for a way to communicate their research outcomes to a wider audience through SGs technology.

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## **Conflict of interest disclosure**

The authors declare that they comply with the PCI rule of having no financial conflicts of interest in relation to the content of the article.

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<sup>8</sup><https://echoes.he.duth.gr/>

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