ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume X-M-2-2025
30th CIPA Symposium "Heritage Conservation from Bits:
From Digital Documentation to Data-driven Heritage Conservation", 25–29 August 2025, Seoul, Republic of Korea

Video Games as a Tool for Heritage Mediation, Application on the Monument of Sennefer in the Theban Necropolis, Egypt

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Keywords: Video Game, Heritage, Sensibilisation, Learning, Architecture.

Abstract

Numerous heritage sites remain inaccessible due to factors such as their state of preservation, physical inaccessibility, or the geopolitical context of their location. Advances in digital documentation technologies provide opportunities to preserve records of these monuments and make them more accessible. Among these digital tools, video games, and more specifically serious games, have emerged as effective mediums for public heritage mediation. This paper explores the potential of serious game development for communicating about heritage sites that are otherwise inaccessible. The chosen case study is the chapel of the Theban Tomb of Sennefer (TT96A), an elite member of the 18th Dynasty of Ancient Egypt, situated in the site of Sheikh Abd el-Qurna, near present-day Luxor. The study demonstrates that the methodology used in developing these tools, such as employing a storyboard, offers a robust means of conveying the historical evolution of such sites. The result is illustrated through a video showcasing the game, available at: https://youtu.be/K1b4P9HSu-E.

1. Introduction

"Through words, buildings or forests become monuments: aesthetically, scientifically and legally distinguished, symbolically remarkable. Little by little, the territory itself became a place of remembrance, when the notion of site made its appearance. [translation by authors]" (Lazzarotti, 2011). Over time, it has become necessary to protect our heritage. "The idealistic goal of heritage protection is their maintenance in the original form and their passing to the coming generations." (Szmygin, 2010). However, this objective is complicated by the current situation of these heritage elements. Some of them have disappeared over time, have been deteriorated, have been reconstructed, or are no longer accessible to the public. This is the case of the commemorative chapel of the funerary complex of Sennefer, which is actually not accessible to the public due to the fragility of its paintings. It is therefore necessary to keep a record of these sites and raise public awareness about them (Hallot, Lambert, & Jouan, 2021). This is why a Belgian archaeological mission (see section 2.1) is underway to inform the general public about the state of the commemorative monument and the results obtained.

This is where digital heritage documentation technologies come into play. New and old buildings can be preserved digitally for future generations, keeping a record of their evolution. This documentation is crucial given the events that may occur, such as wars or natural disasters, which can damage numerous historical sites (Macher & Bagieu, 2023). Heritage documentation techniques help to obtain 3D models, orthophotos, and other representations that are as close to reality as possible. This allows us to address challenges faced in the preservation of architectural heritage by making these sites more accessible while also considering their state of conservation and accessibility (Thise, 2024).

Moreover, in the heritage domain, there are various means of cultural dissemination that can be grouped into two categories: material mediation and immaterial mediation (Bordeaux & Caillet, 2013). The first one includes writings, films, games, fashion and advertisements, while the second one includes visits, events and exhibitions. Caillet (2007) explains how these tools of cultural dissemination can be used to help the visitor to learn and understand the meaning of a work of art. She says that "nothing compares to active methods through which the visitor is led to retrace the path of those who established the displayed knowledge [translation by authors]". This reflection supports the use of game by putting the player in an active learning environment. This is why this paper is centred on serious game.

In addition, currently less visitors come to museums and more of them go on websites to see the various works on display. In response, the museums have begun to adapt to the new consumer society, which is more receptive to technologies, by adding more interactive interfaces (de Sulauze, 2016; Banfi, & Mandelli, 2021). By taking a material mediation tool, such as games, and combining it with digital technology, the public's attention could be captured, and they could understand the value and the excavation method used for the Sennefer's tomb chapel.

This paper is a continuation of research conducted as part of a final master's thesis through a doctoral research. The rest of the paper is structured as follows. The case study and its context will be developed. Next, the methodology will focus on the serious game and the targeted audience. The implementation is then specified through the choice of game type and engine, the storyboard, and the game's design and programming. After that, the results are presented based on the tests conducted, and the limitations of video games are discussed. Finally, we conclude and propose research perspectives.

2. Case of Study

2.1 Introduction to the monument

The funerary complex of Sennefer (TT96) – specifically its chapel (TT 96A) – is part of a UNESCO World Heritage site in Luxor. Closed to the public due to its fragile state (Figure 1), it has been studied for 26 years by a Belgian archaeological mission led by the Université Libre de Bruxelles and the University of Liège.

Figure 1. Sennefer's chapel.

Sennefer was the governor of Thebes and director of the domain of Amun at Karnak during the New Kingdom. His influential ties, notably through his wife, a nurse of King Amenhotep II, secured him privileged access to the Valley of the Nobles (Bavay, & Laboury, 2012). This allowed him to plan and complete his tomb early in his career, unlike many contemporaries.

2.2 Realisation of the chapel

Selecting the site involved three criteria: sacred proximity to his king and Karnak, closeness to influential predecessors or people he knew, and geological suitability for a hypogeum, a funerary chapel carved into the rock.

Once fixed, the orientation was determined by the domain Sennefer administrated and the slope’s alignment. Inspired by Senneferi’s nearby chapel (TT99), from a rival faction, Sennefer enlarged his chapel and later increased the height of the chapel by 70 cm, leaving a clear structural trace of this decision.
Various craftsmen excavated, prepared, and decorated the monument. They worked concurrently (Laboury, 2010) when possible, due to the scarcity and high demand for such labour. Quarrymen marked a central axis on the ceiling, then excavated along it with secondary galleries branching out (Laboury, 2023) (Figure 2). Two excavation methods were used: direct percussion with hammers for rough cutting and indirect percussion with a mallet and a chisel for precision. A past landslide had weakened the rock (Aubry, & al., 2016), requiring careful top-down excavation to prevent collapses. Lower rock sections were reused as scaffolding. Excavated debris was strategically removed and reused to build the terrace, façade walls, and retaining structures, avoiding rock falls that could obstruct nearby tombs.

2.3 Composition of the funerary complex

The complex comprises the burial chamber and the commemorative chapel. The burial chamber, inaccessible in ancient time, is renowned today for its painted vineyard ceiling – hence the name “The vineyard tomb”. The chapel, now closed to the public, is divided into four architectural parts: the transverse hall, the longitudinal hall, the hypostyle hall and the annexe (see Figure 2).

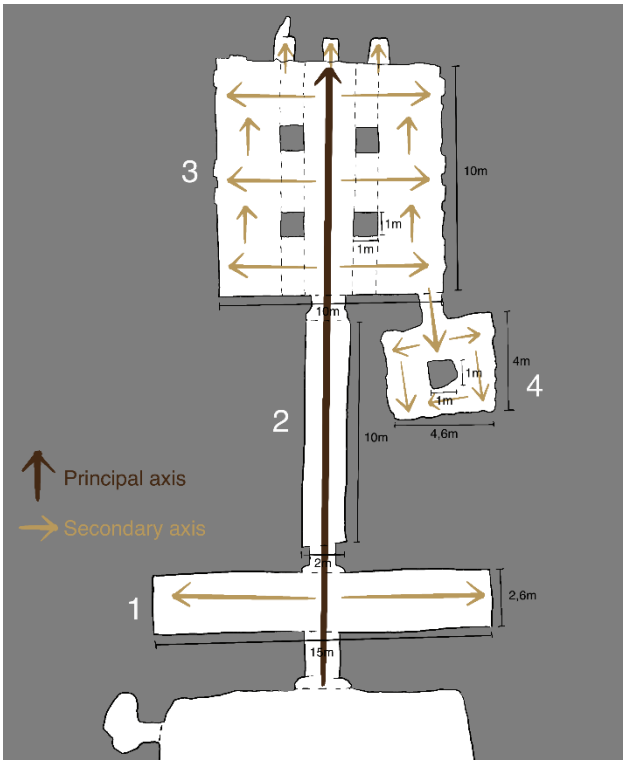

Figure 2. Plan with excavation axis of the Sennefer’s chapel.

The transverse hall (1), wide yet shallow, depicts Sennefer introducing himself to visitors through wall paintings (Angenot, 2007). The narrow, darker longitudinal hall (2) symbolizes the passage from secular to the spiritual realm (Angenot, 2007; Den Doncker, 2007). The hypostyle hall (3) is larger and singular. This type of room is not often found in a chapel (Angenot, 2007), but as previously mentioned, Sennefer took over the layout of Senneferi’s hypogeum who had one. Contrary to him, this room has four central pillars and an annexe (4). This one has a central pillar, but no information explains the presence of this room. However, Laboury (2023) suggests that it might have been a reference to the royal tomb structure.

3. Methodology: a Serious Game Development

3.1 Why serious game?

The Belgian mission has provided a wealth of information about the funerary complex. This monument has architectural and heritage significance that raises questions about its realisation process. Most of them have found an answer, but some elements only generated hypotheses. In addition, the project aims to raise public awareness of the chosen heritage. This led to the decision to use an interactive tool that would engage players, like the serious game.

According to De Grandmont (1997) and Dasen (2024), the use of games in such cases has existed since Antiquity, but games were above all fun. It was only with the passage of time and the intervention of the Jesuit institutes that the potential of games for education was fully realised. But it was not until the 17th century that the notion of educational games appeared, and then only in the 20th century that the modern concept of serious games came into being.

A serious game can be defined as a playful way of conveying utilitarian functions, such as broadcasting a message, providing a

training or promoting the exchange of data. (Alvarez, 2024). Moreover, digital games engage, in a more active way, the players by putting them in a situation where they must interact with the virtual environment (Jouan, Moray, & Hallot, 2022). Video games also allow players to have immediate feedback on their choices, letting them know, in the case of a serious game, if they have understood the content being shared (Ifenthaler, Eseryel & Ge, 2012).

The loss of interest in museums is pushing them to adapt to the digital age and modify their methods of knowledge transmission. To achieve this, they have begun to offer virtual tours, to set up interactive installations and to gamify certain aspects of their exhibitions, both the works themselves and the visit itself (de Sulauze, 2016; Banfi, & Mandelli, 2021). "The introduction of gaming technologies gives significant advantages to the whole cultural heritage domain, enabling users to experience tangible and intangible cultural heritage in a completely new way" (Bontchev, & al., 2024). This interest in gamification, as it provides an opportunity to reach a young audience, led to the decision to use the game as the medium for this project. By taking a material mediation tool, such as games, and combining it with digital technology, we can attempt to capture the public's attention and help them understand the value and the construction method used for the analysed monument.

For some, however, the medium takes up too much space and dissipates the content of the work. Visitors will no longer come for the work itself, but for the interest provided by the tool that mediates it (de Sulauze, 2016). The shortcomings of digitising heritage are not inevitable. It is a consumer choice to prefer the digital version to the physical one, but that does not mean that the physical version can no longer be exhibited. This opens more possibilities for mediation, which can respond to the divergent demands of new generations.

What's more, museums are not the only institutions to use digital technology to share elements of their heritage. There are various platforms offering 3D models of these elements, but there are also games that show artistic concepts (see *Prisme 7*[1]), damaged and/or disappeared buildings/landscapes (see *Assassin's Creed*[2]), highlight certain landscapes or certain atmospheres within them (see *Vestigia Songe*[3]) and so on. All these games touch to the heritage sphere and can be divided into three categories: landscape heritage, artistic heritage and architectural heritage. For this project, it's the architectural heritage that is analysed through the case study. However, the landscape heritage is intrinsically linked to the architectural heritage, as a building cannot exist without its context. Therefore, when studying Sennefer's chapel, research must be extended to the surrounding landscape, because the excavation principles would have been entirely different if it had been realised somewhere else. The creation of the game for this project aims to share the method of excavation but also to inspire players to learn more about heritage. That is why a target audience has been designated and that the game has been designed to adapt to it.

3.2 Target audience

The choice has been focused on 16 to 25-years-olds, students in secondary or higher education levels. These individuals have grown up surrounded by new technologies and the internet. They are accustomed to having access to various information at any time (ATAWAD[4] principle), which has transformed their relationship with information, making them more likely to skim through it. The use of video games in education or sensibilisation can put the students in an active learning (de Sulauze, 2016; Frasca, 2003). This goes against so-called "ex cathedra" lectures, which do not involve students in their own learning.

Furthermore, the use of games, which are not necessarily designed for educational purposes, helps develop various skills in both children and adults, engages and immerses them, while also making learning interactive and enjoyable (Tsai, & al, 2016). The skills developed therefore depend on the type of game offered. It could be a game where the skill is central to it and serves as a sort of goal to be achieved by the end of the game. For example, if we consider the game created for the study, one of its objectives is to demonstrate the chapel's excavation system, so by the end of the game, the player is expected to master the methods used. Moreover, a skill can be developed without it being an explicit goal of the game. Jong & al. (2010) identify three elements that will influence the players' motivation: challenge, fantasy, and curiosity. With flow[5], players will find it easier to take on challenges, even if there is no reward at stake, or to seek out more information within the game. The various possibilities that video games offer for the target audience were considered during the programming of the game created for the study. The game was designed to be adapted to students, their level of knowledge, and their ease of use with this type of tool.

4. Application

4.1 Data acquisition

Data acquisition is made by photogrammetric and lasergrammetric application. The survey conducted during the mission of 2019 to 2021 ends up with a comprehensive point cloud and mesh model of the funeral chapel used in this research. More information about the acquisition process cand be found in the paper of Jouan & al. (2021) and in figure 10.

4.2 Type of game and game engine

Once the data acquisition finished, it was necessary to determine what to do with the game, meaning to develop its storyline and decide the various stages and mini games that would constitute it. Initially, the type of game to be created had to be decided. So, as mentioned before, the serious game was chosen.

Secondly, it was necessary to select between two types of games: ludus (game-based) and paidia (play-based) (Caillois, 1958). The first one is a game with rules with often a principle of victory and defeat. The second one is free of rules, except the rules of the players themself, and there's no victory. To give a purpose to the players, it's the ludus game that was chosen. Various rules will be implemented to guide and keep them engaged in the experience.

[1] Bright & Game in Society (2022). Prisme 7. *Centre Pompidou.*
[2] Ubisoft (2007). Assassin's Creed. *Ubisoft.*
[3] Lelièvre E. & al. (2020). Vestigia Songe. *Vestigia*
[4] Any time, Any where, Any device
[5] A concept developed by Csikszentmihalyi, which refers to the impact of a positive mindset on a task to be accomplished (making it easier to complete successfully).

Thirdly, the choice was made between narrative games and simulation games. Narrative games can be compared to films or books. Players will follow a story without being able to modify it significantly, whereas in a simulation game, they are at the centre of the game, and their choices have a real impact on it (they’re not just a passive spectator) (Frasca, 2003). Thus, the game has leaned more towards simulation games.

Fourthly, we had to decide between a collective game and an individual game. The former fosters cooperation but might lead to some players not sharing their opinions due to group dynamics. On the other hand, an individual game can be played anywhere without the need for others and allows for greater autonomy in the player's choices (to the detriment of collaboration). Nevertheless, the choice was made for the individual game.
Fifthly, the decision was taken for the interactive film genre. This type allows for a story that guides the players’ entire experience while still letting them make choices that impact the following scenes. Therefore, this genre, coupled with simulation, was chosen. Additionally, we decided that the proposed story would follow a convergent simulation, meaning that the ending will be the same for all players, despite the different choices made. Like that, players will feel engaged through their choices, trials and errors, etc., while still arriving at an ending consistent with reality.

After that, we had to choose the game engine. The choice was made to go with Unreal Engine. Indeed, its high 3D resolution, the ability to use Blueprints[6], and the presence of a strong community and training resources influenced the choice of this engine.

4.3 Storyboard

The storyboard visually outlines the guiding line that a project will take, in this case, a video game. It is thanks to the collected data that the different stages were developed. Indeed, as previously mentioned, the game aims to share the steps from choosing the site for implantation to the excavation of the chapel. Thus, the game was divided into several parts: explanatory sections, playful sections, and exploratory sections. These three elements have been presented in such a way as to maintain players' attention, by chaining them together so that none of the sections takes up too much space at once. The storyboard was thus drawn to show this (Figure 3).

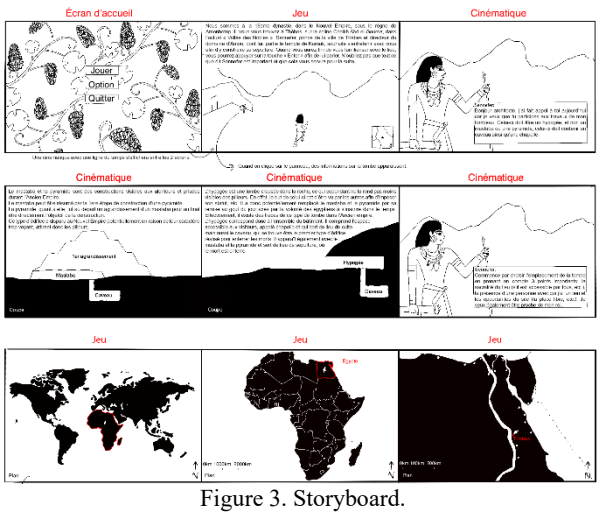

Figure 3. Storyboard.

Players begin with a timeline video that situates them in the period, explaining their mission and for whom it is done. They then meet Sennefer, who asks them to create his hypogeum. The differences between various funerary complexes are explained, so that players understand what a hypogeum is. Sennefer instructs players to choose the site for his monument based on three factors: site sacrality, monumental presence, and geological opportunity. Guided by Sennefer’s hints, the players select the location step by step – continent, country, town, then the valley – culminating in a Google Earth Studio video that zooms from Earth to TT96A precise site. Players then enter an open world. A message explains that potential monument locations are marked by a fire, which can be selected by approaching them and pressing a key. Wooden boards close to the modelled hypogeums provide information about them, and a help key reminds Sennefer's expectations. Once this panel is closed, players take on the role of an ancient Egypt architect, free to move using mouse and keyboard (controls are listed in the menu). They can explore Sheikh Abd el-Qurna hill, visit surrounding monuments, and test several hypogeum locations. Incorrect choices trigger screens explaining the errors – such as being too close to another funerary complex or having too small a gradient – encouraging critical thinking (Figure 4).

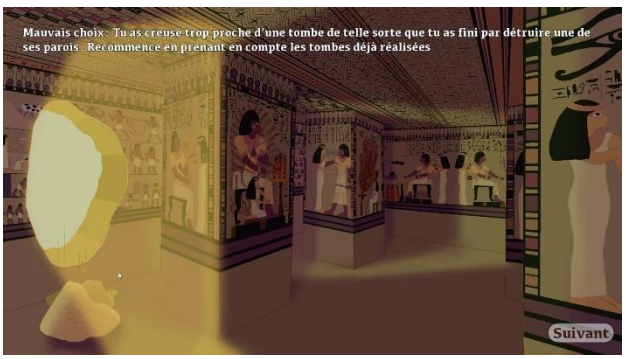

Figure 4. Bad choice screen for the chapel location.

When the correct location is found, its suitability is explained, including soil stratification, past landslides, and rock quality. After this, Sennefer asks to find the correct orientation of the chapel. Then, players arrive on an interactive screen where they can rotate the representation of the chapel with two arrows. The instructions indicate that players need to consider the slope of the hill and the domain that Sennefer oversees, which can be seen on the screen. When players have found the correct orientation, Sennefer tells them to realise the layout of his chapel based on that of Senneferi, but larger and adding an annexe on the right. After this, the players can choose the different parts of the chapel to create the correct layout (Figure 5).

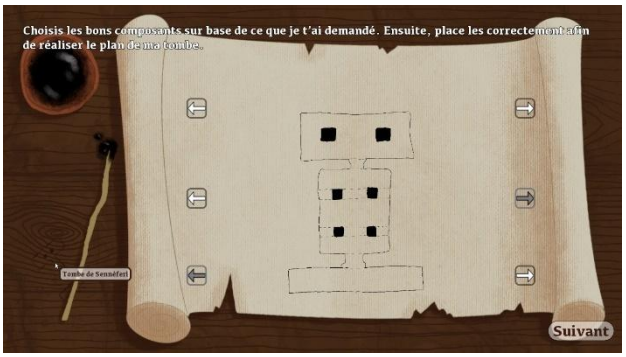

Figure 5. Realisation of the plan.

[6] Visual scripting without code.

Once finished, players can click on the different parts to have more information about them. They need to choose the tools, people, and techniques suitable for the smooth execution of the work, in adequation with the previous explanations. In the techniques, the players must find how to excavate the rock in a section view and in a plan view, how to realise the pillars and what to do with the rock debris. For each choice, a description is proposed to explain why it is correct or not.

After that, Sennefer thanks them and tells them that there is still the finishing stage to complete (plastering and painting) but that will be for another time. He then tells them that they can visit his chapel either in his era or in the present day, as well as the hill in its current state. The credit video then plays, and afterward, the players can visit these three elements (Figure 6).

Figure 6. Visit of the actual chapel.

4.4 Design and programming

To begin with, it was necessary to familiarize oneself with Unreal Engine through training, tutorials, and experimentations. This familiarization also extended to other software such as Blender[7], Google Earth Studio[8], and CapCut[9]. After that, the software Jira[10] was used. This allowed for the creation of a development dashboard for the game (progress tracking of the work, tasks remained to be completed, etc.).

Then, the development of the game was carried out. This work was divided between two people, Alice Thise and Frédéric Thise. The first one worked on the visual aspects of the game, while the second focused on the programming part. The two parts were therefore carried out simultaneously. When a visual element was completed, it was then implemented in Unreal Engine.

For the graphical part, the two chapel models, created by Philippe Sadzot (Jouan, & al., 2021), had to be imported into Blender to generate an FBX file and after transferred into Unreal Engine. The first model represents the current states of the hypogeum and results from the previous data acquisition. The second model was created based on the chapel’s plan to represent it at the time of its excavation, with straight walls (Figure 7).

Figure 7. Complex model and simplified model

This second model was imported into Blender to accurately reflect the era of Sennefer by straightening one of the pillars and reworking the textures to “hide” the damage (Figure 8). This way, the model depicts Sennefer's chapel in the process of ‘being painted’.

Figure 8. Before / After the modification of the textures.

After that, the 2D screens had to be drawn with Procreate[11]. They were used for the menu, explanations, cinematics, and mini games. These drawings were based on the storyboard but also on the research conducted for the project. Next, several videos were created using the CapCut application (introduction to the general information of the game, chronological timeline, and game’s credits). Besides CapCut, Google Earth Studio was also used to create a video starting from Earth and zooming into TT96. This helps players better understands where they are located. Once the 2D screens and videos were created, the playable avatar of the game could be modelled based on representations of Egyptians during the New Kingdom. This was made possible by using the MetaHuman Creator tool, which allows for the creation of a realistic and high-definition 3D humans (Figure 9).

Figure 9. MetaHuman Creator.

In addition to the character's physical appearance, the loincloth of the metahuman was created in Blender, taking care to link it to the metahuman's skeleton and body mesh (exported from Unreal Engine). It was important to have the skeleton to ensure that the loincloth moved correctly with the body once introduced into the game engine. Furthermore, Blender was also used to work on the 3D model of the hill, realised by Pierre Hallot with the previously acquired data. This work involved retrieving the facades and associated courtyards of the modelled hypogeum. However, many of them were of poor quality. Therefore, it was necessary

[7] Free software that allows for creating 3D models and renders, whether static or animated.
[8] Platform that allows for creating cinematics from 3D views available in Google Earth.
[9] Free mobile application for video editing.
[10] Task planning and tracking tool.
[11] Digital raster drawing application.

to recreate the facades of certain monuments using the facades of other ones.

For the programming part, we first had to create the static screens (game menu, cutscenes, etc.). After that, the mini games were implemented, including explanation screen and mini game screen itself. For that, we had to create a component library filled with dialogue boxes, buttons (checkboxes, etc.), selectable elements (areas, objects, etc.), etc.

Afterward, the open world was created. Its size was determined using Google Maps, covering the entire hill and part of its immediate surrounding. From the generated satellite view, an elevation map in bitmap[12] format was created and imported into Unreal Engine as a landscape. It needed to be scaled and reworked to match the actual site (altitude and shape). Subsequently, an auto material[13] was assigned to the landscape to give it a desert-like appearance. Then, the model was sculpted to give it an eroded appearance. Next, the various pre-existing chapel to that of Sennefer were placed according to their actual positions, using the facades and courtyards cut from the hill model. The paths connecting them have been recreated with the spline tool. After that, markers, represented by fires, were positioned in various locations for one of the mini games that allows players to choose the site of TT96 by exploring the open world. These markers were linked to certain static screens through Blueprints, directing player to screens for right or wrong choices. Additionally, as previously mentioned, wooden panels were placed near the hypogeums to give more information about them. Finally, it was necessary to create different in-game levels corresponding to the chapel in its unfinished and current state. To do this, the complex and simplified models were imported into separate levels. Once finished, the game was exported (Figure 10) to be tested by ten contributors.

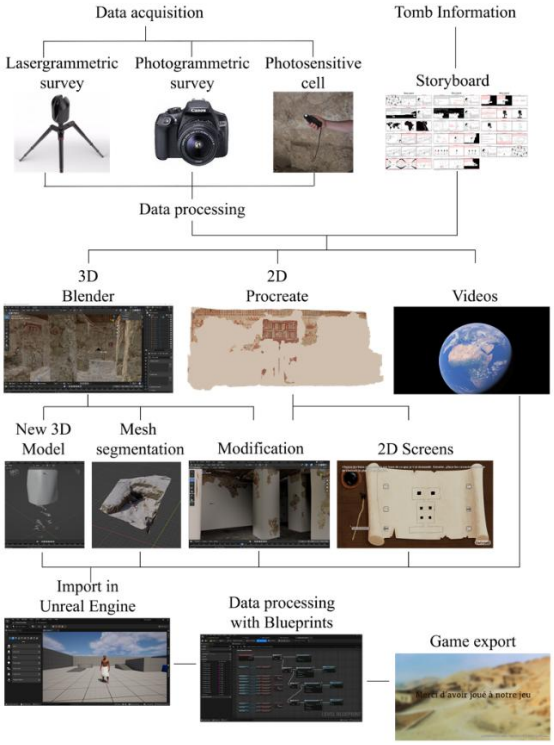

Figure 10. Data workflow of the project.

5. Results

5.1 Feed-backs

To test the game, ten people were selected from students (secondary and higher education) and professors. The group included two architecture students, two art history students, two secondary school students, one architecture professor, one art history professor, one secondary school history teacher, and a specialist on the case study. This diverse sample balanced familiarity with the topic and varied profiles to observe navigation differences.

The testing was divided into three parts: a 5-minute introduction, about 40 minutes of gameplay, and a 5-minutes feedback session – showing that the game can fit into a course. The data collected combined two phases of a qualitative study (with ethical approval): observation during play and post-game feedback via Google Form covering ten questions on user experience and learning outcomes.

Initial analysis shows that a participant’s field of study or profession, apart from the specialist, had little impact on gameplay experience. Age and digital familiarity proved more influential: students navigated mini-games and the open world more easily than professors, retained information better, and made more thoughtful choices. Professors relied more on trial and error. This suggests the game suits its main audience 16–25-year-olds. Students’ digital ease also led to explore more widely, connecting surrounding funerary complexes with Sennefer’s tomb. Professors did explore the hill too, but their approaches varied between random selection and systematic search. Most tester understood the methods used to create TT96A and could recall key factors behind the site’s selection and excavation.

Overall difficulty was rated as easy, though two mini-games – on orientation and layout design – posed challenges, highlighting the need to clearer instructions and reminders. One participant noted the lengthy explanation might lose the attention of younger players; however, this was not unanimous, as more secondary student appreciated the detailed context.

Participants agreed the game could be used in education and is well adapted to its target group, though some recommended adding age-appropriate incentives and frequent reminders of objectives. The game also sparked interest in learning more about the topic and motivated players to visit the real sites, thanks to the virtual tour in both past and present conditions.

Feedback suggested improvements such as simplifying the more complex mini games, adding details about the niches in the hypostyle hall, allowing notetaking and expanding the finishing stage. Players valued the freedom to explore, felt motivated, and did not find the game discouraging despite varying skills levels. The playtime was judged appropriate, and the game’s quality was appreciated.

In response to this feedback, additional reminder screens were added, and more difficult minigames were simplified to better accommodate both students and teachers.

[12] Black and white map where the lighter areas correspond to the highest elevations and vice versa.

[13] A flexible painting material for landscape components in Unreal Engine. The auto material automatically applies different layers of suitable materials [ground textures, wood debris, stones, vegetation, etc.] to the landscape's topology, considering the surface slope (Unreal Engine).

5.2 Contribution of the game

Firstly, developing the game itself raised some questions and helped the author recognize certain aspects. Preliminary research conducted for designing the mini games and their explanations enriched the author’s understanding of the case study. Furthermore, specific questions emerged around the rock excavation process, especially after testing with the specialist. He hypothesized that the ancient Egyptians may have employed multiple excavation techniques, which likely varied based on specific goals and challenges encountered during the process. Nevertheless, the principle of beginning excavation from the top remained constant, regardless of the methods applied. Thus, the mini game demonstrating one excavation method was adjusted to represent all feasible techniques, allowing players to choose between excavating rock in a column-by-column or line-by-line approach (Figure 11).

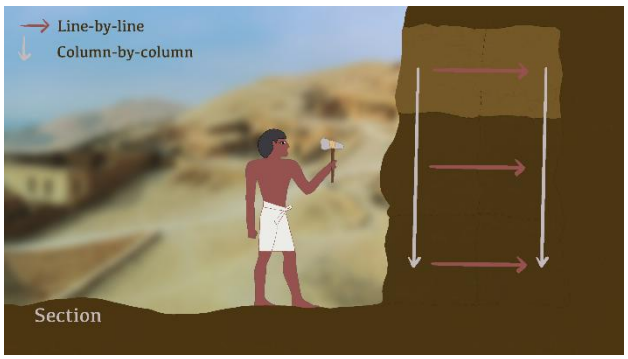

Figure 11. Choice of the excavation method.

Secondly, the testing reinforced several points addressed in the section on the target audience. The ATAWAD principle was observed in one of the younger participants due to the presence of too many explanations and mini games considered more challenging. This once again highlights the importance of tailoring the game to the target audience to ensure it maintains a fun, engaging process that fosters active learning. Additionally, some participants were able to develop secondary skills, such as improved navigation in the game and a better understanding of the sequence of screens. These skills will be beneficial if they decide to incorporate the serious game into their teaching.

5.3 Limits of Video Games

Firstly, it’s essential to recognize that games can modify or simplify reality. Despite high-definition graphics, the content or design of a game may diverge from reality based on its purpose. For example, the modelling of an ancient building may lack accuracy unless detailed references from the time of its construction exist. Elements like room layouts or stone structures may then differ from the historical reality. Moreover, even if a building has been well-documented, a game with a fictional narrative not aligned with historical facts should not be considered a reliable source. Players must therefore be aware of the limitations of this medium to avoid forming misconceptions. When photogrammetry is used to digitally render a building in-game, simplifications are often required to prevent excessive memory usage. Although minor, these alterations still exist. Additionally, game sections are sometimes simplified to improve player understanding and maintain a smooth experience.

In the case of the game in this study, certain historical aspects of floor plans were adapted to prevent overwhelming the player with information and to maintain gameplay flow. Furthermore, the 3D model of Sennefer’s era hill was based on a laser scan of its current state. As a result, some façades may no longer resemble their original forms due to degradation.

Beyond 3D visuals, sound can also diverge from reality. Most games incorporate music to emphasize key moments. For this reason, research for the case study extended to the fauna present during the period to recreate a soundscape that closely resembles what likely existed. This realistic approach primarily applies to open-world environments and not for the videos for which original music was composed.

Secondly, it is essential to recognize that using a game in education requires pedagogical support. A game is a tool, but on its own, it is insufficient and cannot replace a lesson given by a teacher. Instead, it can serve as a supplementary aid to reinforce certain skills and verify knowledge retention.
Moreover, it is crucial to allocate time for feedback on what has been covered, allowing students to retain information rather than merely glossing over it. Additionally, a video game alone does not facilitate face-to-face interaction between a teacher and a student, reinforcing the idea that it cannot replace traditional teaching.

In consideration of these points, the game in this study includes a pre- and post-game period (as explain on point 5.1), to introduce the game and review its content, thereby maintaining a connection between participants and the instructor. The tests further demonstrated the importance of having an instructor to clarify certain game requirements for those who had difficulty understanding, to better explain navigation within open worlds, and to assist with mini games.

Thirdly, some argue that games can highlight superficial learning (Ifenthaler, Eseryel & Ge, 2012). Therefore, games must be selected according to the teacher’s objectives, which should be determined beforehand. According to Coutou (2015), if a game is too simple, students may put in less effort. Thus, it is crucial to strike a balance in complexity so the game is neither overly simple nor overly challenging, as this could lead to student disengagement. She also notes the need to ensure the game does not become overly entertaining, allowing the playful aspect to overshadow the educational one.

Time is also a potential constraint. Implementing a game as an educational tool may not fit neatly within scheduled plans; various external factors, such as player motivation, equipment setup, or instructions’ clarity, can influence the game duration. This was considered for testing by scheduling an hour for each session. Game time varied depending on the participants’ desire to explore or their level of difficulty, averaging around 40-45 minutes, so that the planned timeframe was not exceeded. Furthermore, the game was designed with a heterogeneous difficulty level to accommodate diverse participant profiles. However, as noted, this approach was not entirely effective, as career background had a limited impact on player experience; personality traits influenced it more significantly. Still, the game maintained a range of difficulty through a mix of more challenging and simpler mini games, keeping players actively engaged in problem-solving.

6. Conclusion

The study analysed how video games can raise students' awareness of architectural heritage, specifically focusing on TT96. It highlights the importance of adapting the communication of heritage elements to the new generation while

preserving these elements for future generations. The analysis underscored the educational value of video games, particularly serious games, in an educational context. The target audience was chosen based on the interest in using interactive interfaces with students, who are generally more receptive to such tools.

To achieve this, this article examined the stages of the implantation and excavation of TT96 in the rock. It also included an analysis of games and their impact on students, forming the foundation for designing a serious game suited to the target audience. This development process deepened the author’s knowledge of the topic by prompting various questions. Additionally, the testing phase gathered participants' feedback, highlighting both the benefits and limitations of the game. It was found that students were motivated to learn in an interactive, playful way, enabling them to retain information provided by the game and fostering an interest in further research and visits to the site. However, limitations were identified, such as the modification and simplification of reality, the necessity of pedagogical support, and the inherent limitations of video games as an educational tool.

Nonetheless, the objectives of this work were achieved by sparking curiosity about the studied heritage among participants. The game was generally easier for students to navigate than for professors, underscoring that, while effective, video games are not a universal solution. Their success relies on the game's design quality, its adaptability to all users, the integration of meaningful educational content, and the pedagogical guidance provided to students. Thus, games should not replace traditional lessons but rather complement them, helping students stay engaged in an active learning process.

In conclusion, this study demonstrated the potential of video games in valuing and preserving heritage among students. It highlighted the importance of pedagogical innovation to adapt to today’s context, encouraging students to engage more deeply with their heritage. This research shows the interest to extend this methodological approach to designing a serious game to the whole communication of architectural heritage.

Acknowledgements

We would like to extend our warmest thanks to the participants in the game test, and to Frédéric Thise, for co-creating the game. Without them, this work would not have been possible.

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