3D GAMING FOR YOUNG GENERATIONS IN HERITAGE PROTECTION: A REVIEW

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ABSTRACT:

Heritage buildings, landscape, and structure are threatened because of natural disasters, development pressure, and might be deserted due to high maintenance costs and lack of people awareness. To preserve community values and pass them from generation to generation, protecting heritage is essential. In some countries, the awareness to preserve heritage arises strongly among young generation through different types of organisations. In Indonesia, many young people, such as university students, architects, journalists, historians, and academics, have strong willingness to learn and protect cultural heritage. However, they have limited support to do that. 3D games, Virtual Reality (VR), and Augmented Reality (AR) technologies are considered effective means in teaching about heritage. Moreover, in urban planning, these technologies especially 3D game is used to involve young people in taking part to design the city. Therefore, similar technologies could be utilized to facilitate young people in heritage protection. Certain functionality should be ensured to allow engaging activities such as taking decision, sharing opinions, and expressing creativity. This paper presents a literature review on the use of 3D games and similar technologies for heritage in the last five years. The study shows that the literature related to this topic is still very limited, i.e., only 14 articles focus on the topics of 3D gaming technology and heritage.

1. INTRODUCTION

The needs of preserving heritage in the form of 3D digital model has become an international priority as many heritage are threatened from natural disasters, erosion, climate change, and development pressure (Alshawabkeh et al., 2020; Bekele, 2019). Protecting heritage is crucial because it could preserve community's values and to pass them from generation to generation (Harrison, 2012).

It is important to engage young people in heritage preservation, because they are the next generation to become responsible for it. Young people, and specifically students and young professionals are become increasingly active in different societies or organisations. In Southeast Asia, heritage organization that is formed by local resident or also known as civil society has a great role in the protection of heritage (Roberts, 2017). In Indonesia, civil society is usually initiated by the young people. For instance, in *Kampung* Peneleh (Peneleh Urban Village), Surabaya. The community has succeeded to protect the heritage site (the environment where the first President of Indonesia was raised). The people who started this activity were university students along with their professors. Together they work with the Peneleh community to hold several events in the effort of preserving the environment. The activities are varied namely, holding old photos competitions to collect historical evidence, mapping important spots in the village, and planning the maintenance of the urban village for the future (Perkasa, 2021).

The involvement of community especially the young generations can be stimulated by using 3D technologies and specifically games (Joseph Agbo et al., 2022; Poplin, 2014). They can use the 3D game to work with the community in mapping the historical spots, to discuss what to preserve, to plan the maintenance, or simulate the change of heritage buildings or environments. Furthermore, 3D games offer an attractive visualisation and interaction that can attract more young people to join the preservation. To date, 3D modelling has been used by the researchers to document and promote heritage to the students (Kyrlitsias et al., 2020; Ocón, 2021) but to involve them in the more stimulated activities is still very limited.

In some other domains, such as urban planning, the involvement of students has been actively promoted. Therefore, many designers have put effort in encouraging them to give idea to plan their city. Poplin 2014 developed a serious 3D game to design the city. In the game, the students can modify buildings, parks, and other urban features. They can also play together with their peers and exchange opinions about the design. Similar approach can be followed for heritage. However, this type of functionality is not currently available in the 3D games developed for heritage applications. The applications focus mostly on visualisation and explorations of heritage building and cities.

A search in the research repository Science Direct revealed only 14 articles that are relevant to 3D gaming and heritage. In contrast, the number of papers that is closely related 3D modelling for heritage is rapidly growing with more than 4000 peer-reviewed journal articles. Most of the articles on 3D modelling are on digitizing heritage and visualizing it on interactive platforms such as in Biljecki et al., 2015 and Trapp et al., 2012. Approaches to create 3D models for heritage are developing quickly with special attention to the preserving the complexity of shape (Brumana et al., 2022), ensuring high accuracy, and dealing with heterogeneity of end users (Shabani et al., 2021). These are very positive developments, and they have to be further extended to provide more functionality.

Therefore, this article presents a literature review of the usage of 3D games for heritage documentation. The goals of this study are, firstly, to understand the current state of the development of 3D game heritage. Secondly, to explore the functionality that the

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systems provide. The paper is organized into four sections. Section one quickly introduces the motivation of providing young people a 3D game in heritage protection. Section two presents methodology on the method for collecting and extracting research articles and the method for analysing the 3D games based on several criteria. Section three consists of the result of extracted journal articles and the analyses of the available 3D games for heritage. Lastly, section four presents the conclusion of the review.

2. METHODOLOGY

This literature review is conducted in two steps. Firstly, the selection of research articles from Science Direct is completed by applying keywords that relate to the topics of interests. Secondly, criteria are determined to analyse the systems and developments reported in the literature.

2.1 Keywords to Extract Articles

Science Direct is selected as a journal database repository to collect the research articles. The following keywords are applied to obtain expected publications:

a. 3D modelling
b. Serious gaming
c. Cultural heritage
d. Architecture
e. Virtual Reality
f. Augmented Reality

The terms "3D modelling" is chosen to obtain articles in the topic of heritage that focus on 3D modelling. Since 3D is a very quickly developing area, the expectation is to filter the articles that have 3D component. The second keyword is "serious gaming". This keyword is selected to obtain the articles that utilize the 3D modelling for the purpose of education. Next, the term of "cultural heritage" is chosen because it is often used to represent heritage that is in the form of buildings, landscape, and structure. Thus, it is expected to exclude articles that discuss other forms of heritage such as language, dance, music, etc. The use of "architecture" is also expected to help finding articles that focus on architecture heritage. "Virtual Reality" and "Augmented Reality" are used because those terms are popular nowadays in the topics of heritage.

The research articles in the last five years (2018-2022) are selected to be analysed. Next, to eliminate the publication out of scope, a thorough reading on each article is conducted. A substantial period of time was dedicated to the articles that report research on 3D game heritage for young people. Eventually, the articles that were considered relevant were using minimally three important keywords namely, 3D modelling, cultural heritage, and gaming.

2.2 Criteria to Classify Articles

The selected articles that are obtained from Science Direct then are to be classified according to the following criteria:

1. Types of users. This criterion is important to understand and classify whether the user(s) can be classified as community (general people) or young people (school students/university students) or the experts (architects, archaeologists, museum operator, academics, etc.)
2. Purpose of the developed application, e.g., for visualisation, education game, tourism, or etc.
3. Type of objects is criterion that attempts to identify if the 3D model contains parts that are modelled as individual objects (windows, doors, facades, etc.), or only one model
4. Additional information about the modelled site, such as images, text, and video that can help the users get better understanding about heritage
5. Interaction and graphic user interface to learn about interactions that the 3D game/platform/application provided
6. Game engine to identify the commonly used game engine software for heritage applications
7. Data source to identify the needed data for different types of heritage site or artifacts to create a 3D game/platform/application

3. ANALYSIS

3.1 Classification of Papers

The hits have shown that this area is relatively underdeveloped in the last five years. With the set of keywords "3D modelling, serious gaming, cultural heritage, architecture, Virtual Reality and Augmented Reality", only 14 articles were found. The highest number of research articles, i.e., five articles, was in 2019. After 2019 the trend is slowly fell down and in 2022 the number of published articles is stabilising (Figure 1).

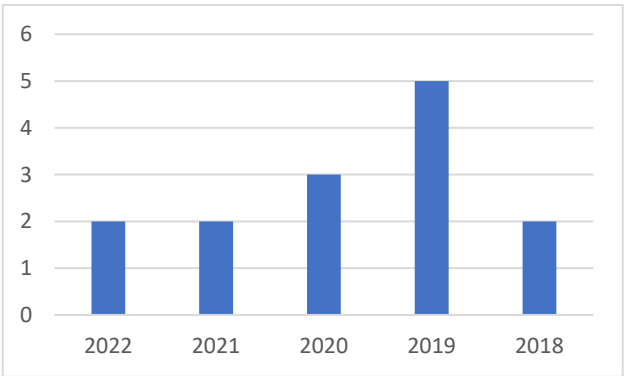

Figure 1. Research Trend for The Past 5 Years

These 14 articles discuss the usage of 3D models in the form of serious games, VR, and AR. These articles are coming from ten journals namely, Digital Applications in Archaeology and Cultural Heritage, Computers and Electrical, Engineering, Entertainment Computing, International Journal of Disaster, Risk Reduction, International Journal of Human-Computer Studies, Journal of Cultural Heritage, Journal of Hospitality, Leisure, Sport & Tourism Education, Pattern Recognition Letters, Pervasive and Mobile Computing, and Technological Forecasting and Social Change. The most contributed journal is Digital Applications in Archaeology and Cultural Heritage with total five articles. The rest of the journals are contributing only one article to the expected topics.

3.2 Types of Users

From 14 articles, six of them are targeting students as the users. Smith et al., 2019 developed a virtual learning content of Roman Palace for the school students, Hincapié et al., 2021 created an application to teach heritage to the university students through AR, Chiao et al., 2018 developed a tour-guiding platform for the university students to explore a heritage city, and Metikaridis & Xinogalos, 2021 created a location-based game for the middle school students to learn about Kilkis history. The remaining

seven articles are targeting general people. The classification of the users in this paper is as follows:

1. Young people (students)
2. Community (everyday people, museum visitors, citizen)
3. Experts (archaeologist, architect, curator, museum operator, etc.)

From 14 articles, six articles are dedicated to the community, one article is for both the community and the expert, two articles are dedicated to the expert, and the rest five articles are for the students (Table 1).

Author(s)	Users	Classification
Allal-Chérif, 2022	Visitor of a digital cathedral	Community
Bozzelli et al., 2019	Exhibition visitors	Community
Ferdani et al., 2020	Exhibition visitors	Community
Petrelli, 2019	Museum visitors	Community
Szczepanek et al., 2022)	Local people	Community
Bruno et al., 2019	Exhibition visitors and divers	Community and experts
Kyriakou & Hermon, 2019	Museum visitors	Community
Sinitò et al., 2020	Museum visitors	Community
Cannavò et al., 2020)	Exhibition operator	Expert
Kosmopoulos & Styliaras, 2018	Curator	Expert
Metikaridis & Xinogalos, 2021	Middle-school students	Young generation
Smith et al., 2019	School students	Young generation
Hincapié et al., 2021	University students	Young generation
Chiao et al., 2018	University students	Young generation

Table 1. Types of Users

The 3D applications that are offered to the community are:

1. Visitor experience using VR, AR, and Artificial intelligence in three Cathedrals (Allal-Chérif, 2022)
2. VR/AR framework for user-centric interactive experience of cultural heritage (Bozzelli et al., 2019)
3. Virtual reconstruction of a house museum (Petrelli, 2019)
4. Temporary flood marks system (Szczepanek et al., 2022)
5. Natural interaction in a Museum Augmented Reality System (Kyriakou & Hermon, 2019)
6. Interactive platform to experience tours and education on the rocks(Sinitò et al., 2020)
7. Underwater cultural heritage exploration both for museum visitor and divers who do the underwater survey (Bruno et al., 2019)

For the experts:

1. A visual editing tool (Cannavò et al., 2020)
2. A Personalised content services in museum (Kosmopoulos & Styliaras, 2018)

For the young people:

1. A location-based game (Metikaridis & Xinogalos, 2021)
2. An interactive exploration of cultural heritage (Smith et al., 2019)
3. An augmented reality mobile apps for cultural heritage reactivation (Hincapié et al., 2021), and
4. An online virtual tour-guiding platform for cultural tourism education (Chiao et al., 2018)
5. Immersive VR application and game to learn The Forum of August in Rome (Ferdani et al., 2020)

3.3 Purpose of applications

The purpose of applications presented in the articles are varied. The most common goal developed for heritage is visualisation with seven articles using different technologies such as VR, AR, and game engines. Another favourable goal is educational game that offers an interactive gaming with four articles focus on learning heritage by gaming. The rest of the applications are more specialised as explained later (Table 2).

Purpose of applications	Articles
Visualisation	7
Educational Game	4
Personalised content service	1
Editing Tools	1
Flood mark recording	1
Total	**14**

Table 2. Purpose of Applications

The seven articles that mention visualisation are mostly aiming to explore heritage site or building. Smith et al., 2019 presented an interactive exploration of Fishbourne Roman Palace complex. Allal-Chérif, 2022 proposed A VR and AR application to explore 3 old cathedrals namely Notre-Dame de Paris, Cathedral Church of Saint Peter in Exeter, England, and Catedral de Santa María de la Sede in Seville, Spain. Hincapié et al., 2021 presented an AR application for the exploration of heritage market, Cisneros. Bozzelli et al., 2019 presented an interactive virtual experience of the temple, the Hera II Temple of Paestum of Paestum. Kyriakou & Hermon, 2019 proposed an AR application to explore artefact in Leventis Museum. Bruno et al., 2019 proposed an exploration of the underwater archaeological sites (shipwreck). The last, Sinitò et al., 2020 presented an interactive web application to experience tours on the historical rocks. For this type of purpose, immersive and non-immersive experience are offered. In the museum such as in Kyriakou & Hermon, 2019, visitors are encouraged to touch virtual artefacts using a head-mounted display (Figure 2).

Figure 2. A Museum Visitor Interacts with Virtual Artefact
Source: Kyriakou & Hermon, 2019

The next four articles propose Educational Games. Petrelli, 2019 developed a game called *View of the Past* to compare a house museum in the present and the past using VR and AR. Chiao et al., 2018 presented a 3D virtual and game-based tourist application to enhance tourist understanding about a place by finding a destination, answering questions, or solving problems at certain scenic locations. Metikaridis & Xinogalos, 2021 presented a location-based game that allows the users to detect an object (Android), run after it, and capture it in the effort of learning the heritage city of Kilkis (Figure 3). Ferdani et al., 2020 developed a VR game to learn about the ancient public squares called The Forum of August.

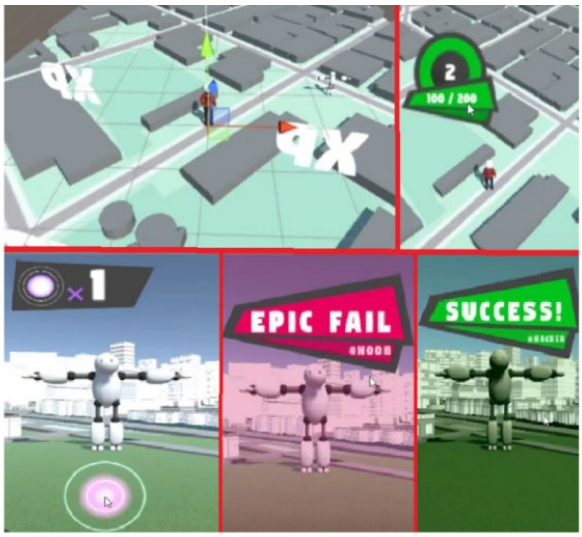

Figure 3. Educational Game. Source: Metikaridis & Xinogalos, 2021

Another application focused on a guidance system in the museum. Kosmopoulos & Styliaras, 2018 aimed to collect information about how to combine user profiling, indoor localization, and content visualisation. With this application, the curator can get relevant report of how the visitor interact with the artefact. Thus, it can help the curators to obtain a reliable and objective measure of the impact of the exhibition.

Cannavò et al., 2020 created an application to provide editing functionality to modify the 3D model such as change tiles, repaint, add voice, and add or remove objects. In this application, the expert (museum operator) can create a 3D interactive interface to present museum's collection to the visitors. This application is dedicated to operators with less programming skills. They can edit and create a 3D application through a visual script called, VSE (Visual Scene Editor) (Figure 4) to manage heritage objects.

The last article proposed a flood mark recording (Szczepanek et al., 2022). According to Szczepanek et al., 2022, flood marks have been used as a way to preserve the memory of extreme floods. Thus, they proposed an approach to engage the community to take pictures of flood mark on important buildings using their smart phones. In this article, the authors aimed to recreate the oldest historical flood water marks in Poland and record the level of high water during and after the flood with the photographs taken by amateurs.

Figure 4. Application for Editing Tools. Source: Cannavò et al., 2020

3.4 Type of Objects

This criterion aims to identify whether the 3D model contains parts that are modelled as individual objects (windows, doors, facades, etc). However, most of the authors did not clearly mention how they have created the 3D model. The authors mostly discussed the development of the application rather than the 3D modelling process. Some insights about the modelling approach can be gathered only from the provided functionality. There are three articles that clearly specified that the 3D model contains more objects. These are Ferdani et al., 2020, Smith et al., 2019 who divided the object into roof, columns and stairs, and Petrelli, 2019 who divided the 3D models of house-museum into table, piano, books, and other interior features.

Two articles used images rather than 3D models namely Szczepanek et al., 2022 that used photographs from the local people to the developed system to present the flood mark and Allal-Chérif, 2022 that used the existing 360º photographs to present the cathedrals on the VR application.

In the remaining eight articles the 3D models are presented in one surface (textured model). Cannavò et al., 2020 presented a textured model of the half body of Queen Neferti. Hincapié et al., 2021 presented a textured model of Medellin's Cisnero Square Metikaridis & Xinogalos, 2021 presented the model of city of Kilkis in the form of boxes. Bozzelli et al., 2019 presented a textured 3D of temple. Kyriakou & Hermon, 2019 presented museum's artifact in one model. Bruno et al., 2019 presented a textured model of historical underwater shipwreck. Chiao et al., 2018 presented one model of heritage building. Kosmopoulos & Styliaras, 2018 presented an artifact in one surface model. The last is Sinitò et al., 2020 presented textured rocks (Table 3).

Type of objects	Articles
Sub divided: roof, wall, floor	3
Images	2
One surface/ textured mesh	9
Total	**14**

Table 3. Type of Objects

3.5 Additional Information

The applications commonly offered a variety of additional information to improve user's understanding about heritage. This information is usually in the form of text, image, audio, and

video. Six articles provide similar types of additional information namely, text, sound, images, and video. The authors that are using this additional information are: Smith et al., 2019 to support the creation a learning material and assessment in the 3D game application, Allal-Chérif, 2022 to help the tourists understand the history in the exploration of old cathedrals, Bozzelli et al., 2019 to present the story about the palace of Nero, Petrelli, 2019, to present the narratives of cultural heritage in an entertaining way through a 3D game, Cannavò et al., 2020 to facilitate the less-skilled museum operator in creating an interactive platform, and Kosmopoulos & Styliaras, 2018 to present the content of museum guidance systems.

One article used photograph, audio, and text in a mobile application by giving an old photographs and information about the events using text and audio (Hincapié et al., 2021). Three articles used text such as Ferdani et al., 2020 to present the information about statues, decorations, ritual ceremonies, Chiao et al., 2018 to explain about the scenic spots, and Szczepanek et al., 2022 to give information about the approximate and relative elevation of the plaque from flood above ground level. The last four articles used text and image to present the information about an old city (Metikaridis & Xinogalos, 2021), to give detail information about the rocks and heritage buildings (Sinitò et al., 2020), to guide virtual diving (Bruno et al., 2019), and to provide historical information of the artifact (Kyriakou & Hermon, 2019) (Table 4).

Types of additional information	Articles
Text, sound, images, video	6
Photographs, audio, text	1
Text	3
Text and image	4
Total	**14**

Table 4. Additional Information

3.6 Interaction and Graphic user interface

Types of interaction and graphic user interface that are offered by prior researchers are quite different. Starting from clicking a button to get information (Hincapié et al., 2021; Smith et al., 2019), pinching the artifacts (Kyriakou & Hermon, 2019), collecting objects through VR environment (Ferdani et al., 2020), real diving to get the photographs of underwater shipwreck through AR application and virtual diving using VR application (Bruno et al., 2019), picking artefacts and playing narrational information in VR environment such as in (Petrelli, 2019), modifying objects (Cannavò et al., 2020), playing and interacting with Android avatars (Metikaridis & Xinogalos, 2021), and clicking the buttons to teleport to the certain location on the map (Sinitò et al., 2020). (Table 5).

To accommodate these interactions, several graphic user interfaces are used. Most of the authors are using in-house interface. Eight authors reported that they have created their own interface:

1. I-PETER (Sinitò et al., 2020)
2. Citizenship, Gathering, Pocket Droids Go (Metikaridis & Xinogalos, 2021)
3. Visual Scene Editor (VSE) (Cannavò et al., 2020)
4. Cultural Tourism Digital Guiding Platform (CTDGP) (Chiao et al., 2018)
5. Visas (Bruno et al., 2019)
6. µVRForum (Ferdani et al., 2020)
7. ArkaeVision (Bozzelli et al., 2019)
8. Vítica application (Hincapié et al., 2021)

The in-house interface is quite popular because researchers can develop a custom interaction. One of the interfaces is I-PETER, an application to explore ancient city. In this application, the users can explore a digital map, do a tour to heritage destinations, and explore ancient artefact (Sinitò et al., 2020) (Figure 5). The second interface called Citizenship, Gathering, Pocket Droids Go. These interfaces are mobile game-based and inspired by the game called Pokemon Go. According to the authors, this interface can be very effective in attracting young users to learn about heritage (Metikaridi, 2021).

Cannavò et al., 2020 also created their own graphic user interface called the VSE, which contains attractive visual buttons (Figure 4). Next is CTDGP by Chiao, 2018, who presented a tour guiding platform. In this interface, the tourists can manage their travel itinerary, get information, and see the available transportation via interactive map and 3D street view. The interface by Visas by Bruno et al., 2019 facilitated a real diving and virtual diving that allows the exploration of the shipwreck of Cala Minnola using an underwater tablet. µVRForum created by Ferdani et al., 2020 to present a game to learn about the Forum of August. ArkaeVision by Bozzelli et al. 2019 to allow the users to point and select with a gesture-based recognition and a cybernetic glove. The Vítica application by Hincapié et al., 2021 is used as an interface for a mobile-based application to learn about the story of heritage market.

Besides in-house graphic user interface, some authors have used the available software such as PlayStation to present their educational 3D games (Petrelli, 2019; Ferdani et al., 2020), Fly View (Allal-Chérif, 2022), Fuvoria (Kyriakou & Hermon, 2019), Android Studio and XCode (Kosmopoulos & Styliaras, 2018), and Google Street View (Szczepanek et al., 2022) (Table 6)

Author(s)	Interaction
M. Smith et al., 2019	Click to get information and to do assessment
Allal-Chérif, 2022	Zoom in and zoom out to locate inside a map, move from one side to the other, access videos, and attend a performance
Hincapie et al., 2021	Click the button to get photographs, audio, and textual information
Bozzelli et al., 2019	Point and select with a gesture-based recognition and a cybernetic glove
Kyriakou & Hermon, 2019	Pinch and hold the virtual object
Ferdani et al., 2020	Walk, find misplaced items, put them back to the initial place by selecting “grab” and “release” using controller
Bruno et al., 2019	Divers: click to photo the underwater shipwreck using augmented diving system Museum visitors: explore the 3D reconstruction of the Cala Minnola shipwreck site using joystick
Petrelli et al., 2019	Pick the artefact, click to play snippets of narratives (as audio)

Author(s)	Interaction
Chiao et al., 2018	Not mention
Cannavò, 2020	Create a 3D interactive application: create object, add sound, and animation
Metikaridis & Xinogalos, 2021	1) click to request citizenship, information, visit monument, and asked some questions. 2) detect an android on the map, 3) select it by touching its icon on the screen,
Kosmopoulos & Styliaras, 2018	Not mention
Sinitò, Diego 2020	Click to get information, locate him/her inside the map of the city
Szczepanek et al., 2022	Not mention

Table 5. Types of Interaction

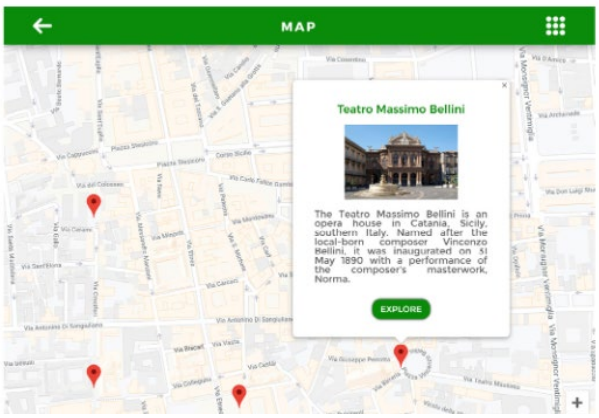

Figure 5. I-PETER interface. Source: Sinitò et al., 2020

Graphic User Interface	Articles
Fly View	1
Fuvoria	1
Play station	2
Android Studio and XCode	1
Google Street View	1
In house	8
Total	**14**

Table 6. Graphic User Interface

3.7 Game Engines

Game engines play an important role in creating a serious game, VR, and AR for the visualisation. The game engines software that is used in the literatures are presented in Table 7 with Unity3D as the most used game engine. Even though Unity3D is popular among the researchers, Smith et al., 2019 concluded that Unreal Engine is the most cost-effective. They make a comparison between four game engines namely, Unity, CryEngine, Torque, and Unreal to create an interactive learning content about Fishbourne Palace. They concluded that Unreal Engine is the most inexpensive one, which provides a high visual quality and user support. Torque is also considered cost effective, however, a slightly decreased visual quality has been observed. The visual quality in Unity3D sometimes becomes a challenge, however, it can be overcome by using the pro version. CryEngine offers a great audio-visual and function, however, it comes with a higher cost.

Similar to Smith et al., 2019, Metikaridis & Xinogalos, 2021 compared three game engines namely, Unity3D, Taleblazer, and ARIS. They concluded that TaleBlazer is suitable for educational role- based games, ARIS is good for hybrid story-based games, and Unity with Mapbox favors the development of recreational action-based games. Only one author that used in-house game engine namely, Bozzelli et al., 2019 that developed an application called ArkaeVision to represent a way to explore a 3D environment with an engaging storytelling applied to two cases: Hera II Temple of Paestum with Virtual Reality (VR) technology, and the exploration of the slab of the SwimmerTomb with Augmented Reality (AR). The remaining three articles are not mentioning the game engine that they have use (Table 7).

Game Engine Software	Articles
CryENGINE, Crytex, Unity, Unreal	1
Unity	8
Taleblazer, ARIS and Unity	1
In house	1
Not clear	3
Total	**14**

Table 7. The Used Game Engine Software

3.8 Data source

Existing 3D models and images are the most used data source in the literature. There are four articles that used existing 3D model and five articles that used image as the data source. It is also common to combine several types of data source such as image and maps, or point cloud, images, and maps to present the best visualisation on the designed application. Generally, the selection of data source depends on their availability and the budget of the researchers.

Previous literatures show that from 14 articles, the 2D plans is rarely used as a data source. Only one article mentioned 2D plans to create their application (Smith et al., 2019) and one article did not mention their source of data (Hincapié et al., 2021) since the focus of the article was more on the development of the AR application (Table 8).

Data Source	Articles
Existing 3D	4
Image	5
Image, maps	1
Point cloud	1
Point cloud, images, maps	1
2D plans	1
Not clear	1
Total	**14**

Table 8. Data Source

The selection of data source can be influenced by the scale of the heritage that is divided into three categories namely, small, medium, and large. In the literature, data such as maps were

mostly used for the medium to large-scale heritage. Large-scale heritage consists of city market (Hincapié et al., 2021), cultural city (Chiao et al., 2018), archaeological site (Ferdani et al., 2020), and small heritage town (Metikaridis & Xinogalos, 2021).

The data such as images, point-clouds, and 2D plans were mostly used for the medium-scale heritage such as palace (Smith et al., 2019), museum (Petrelli, 2019), church (Allal-Chérif, 2022), temple (Bozzelli et al., 2019) and shipwreck site (Bruno et al., 2019). Lastly, data like existing 3D models were mostly used for small-scale heritage such as artefact (Kyriakou & Hermon, 2019), (Cannavò et al., 2020) and (Kosmopoulos & Styliaras, 2018) and heritage rocks (Sinitò et al., 2020).

4. CONCLUSION

This paper presented a literature review on the use of 3D models and environments for heritage preservation. The articles published in the last five years are not many, but this is due to the very restrictive key words. The review excluded 3D reconstruction approaches and general 3D data structuring for heritage. Nevertheless, the results obtained are quite insightful for developing 3D game applications.

The literature review has shown the functionality offered by the applications depends on the type of users. Visualisation is offered to the community, editing and guidance systems are offered to the experts, and 3D games are offered to the students. It can be seen from the first two criteria namely, types of the users and the purpose of applications, that researchers pay more attention to the young people rather than to community by giving them a playful learning environment via 3D games to improve their understanding about heritage.

In the 14 articles, researchers are mostly focusing on the development of their applications rather than 3D modelling process. Therefore, it is uncertain what type of 3D model has been utilised. From visual inspection and provided functionality is seems that most of the 3D models are textured surfaces with no specific object identification.

In contrast, the explanation about the provided interaction and graphic user interface are clear. Generally, the authors choose to create their own graphic user interface (in-house) to realize their expected interaction in a more flexible way.

To create the VR, AR, and 3D game, researchers are generally using Game Engine. To date, the available game engines software is diverse and Unity3D is the most liked game engine among researchers. Nevertheless, Unreal is gaining attention as it offers high quality visual with inexpensive cost.

On the basis of the 14th reviewed articles, it can be concluded that the data source to create a 3D application and game are mostly in the form of 2D plans, image, map, point clouds, and existing 3D models. The selection of data source usually depends on the scale of heritage namely, small, medium, and large-scale heritage. The large-scale heritage such as city usually uses maps as their main data source. The small and the middle-scale heritage are rarely using maps, but they use 2D plans, images, point clouds, and existing data source. It should be noted that a large body of research is conducted on 3D modelling approaches. These are outside the scope of this study.

It can be said that the works on the 3D games for heritage today have offered many functionalities using various software and data source. Traditional interactions like pointing at an object and requesting information in the immersive environment can attract the attention of the young people in learning heritage. Moreover, the interaction like modifying properties or attributes of 3D objects can give a better motivation to young people to play, study, and understand the importance of heritage sites.

Therefore, combining existing concepts and generating new ideas for developing attractive 3D interactive environments is a promising approach to involve young people in heritage preservation. A playful game with a nice visualisation and the possibility to modify the 3D model could be a suitable media to help them learn and preserve heritage.

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