POLITECNICO DI TORINO
Repository ISTITUZIONALE

Online games as a pathway to elevate world cultural heritage conservation in China

Original
Online games as a pathway to elevate world cultural heritage conservation in China / Li, R., Liang, X.. - ELETTRONICO. - (2024), pp. 667-681. (eXploA UID 2024. Virtual Journeys to discover inaccesible heritages Rome (Italy) 15 March 2024).

Availability:
This version is available at: 11583/2998201 since: 2025-03-10T13:29:45Z

Publisher:
PUBLICA

Published
DOI:

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

(Article begins on next page)

07 October 2026

unione italiana disegno

eXploRA

virtual journeys to discover *in*accessible heritages

a cura di

Francesco Stilo
Vittoria Castiglione
Irene Cazzaro
Michela Ceracchi
Fabrizio Natta
Marta Pileri
Lorella Pizzonia
Andrea Tomalini
Noemi Tomasella
Maria Bélen Trivi

PVBLICA
SHARING·KNOWLEDGE

PVBLICA

COMITATO SCIENTIFICO

Marcello Balbo
Dino Borri
Paolo Ceccarelli
Enrico Cicalò
Enrico Corti
Nicola Di Battista
Carolina Di Biase
Michele Di Sivo
Domenico D'Orsogna
Maria Linda Falcidieno
Francesca Fatta
Paolo Giandebiaggi
Elisabetta Gola
Riccardo Gulli
Emiliano Ilardi
Francesco Indovina
Elena Ippoliti
Giuseppe Las Casas
Mario Losasso
Giovanni Maciocco
Vincenzo Melluso
Benedetto Meloni
Domenico Moccia
Giulio Mondini
Renato Morganti
Stefano Moroni
Stefano Musso
Zaida Muxi
Oriol Nel.lo
Joao Nunes
Gian Giacomo Ortu
Giancarlo Paba
Rossella Salerno
Enzo Scandurragher
Silvano Tagliagambe

Tutti i testi di PUBLICA sono sottosposti a *double peer review*

eXploЯA UID 2024

Premio Giovani UID Vito Cardone 2023
Giornata di Studi Internazionale. Roma, 15 marzo 2024.

COMITATO SCIENTIFICO

Leonardo Baglioni / Sapienza Università di Roma
Carlo Bianchini / Sapienza Università di Roma
Enrico Cicalò / Università degli Studi di Sassari
Edoardo Dotto / Università degli Studi di Catania
Laura Farroni / Università degli Studi Roma Tre
Francesca Fatta / Università degli Studi di Reggio Calabria
Fabrizio Gay / Università IUAV di Venezia
Elena Ippoliti / Sapienza Università di Roma
Massimiliano Lo Turco / Politecnico di Torino
Valeria Menchetelli / Università degli Studi di Perugia
Alberto Sdegno / Università degli Studi di Udine
Roberta Spallone / Politecnico di Torino
Graziano Mario Valenti / Sapienza Università di Roma

Pedro M. Cabezos-Bernal / Universitat Politècnica de València (Spain)
Fabiana Andrea Carbonari / Universidad Nacional de La Plata (Argentina)
Livio De Luca / CNRS (France)
Fernando Gandolfi / Universidad Nacional de La Plata (Argentina)
Mona Hess / Universität Bamberg (Germany)
Pedro António Janeiro / Universidade de Lisboa (Portugal)
Piotr Kuroczyński / Hochschule Mainz – University of Applied Sciences (Germany)
Dominik Lengyel / Brandenburgische Technische Universität Cottbus-Senftenberg (Germany)
Sander Münster / Friedrich Schiller University Jena (Germany)
Pablo Rodríguez-Navarro / Universitat Politècnica de València (Spain)
Renato Vizioli / Universidade Presbiteriana Mackenzie (Brazil)
Simone Helena Tanoue Vizioli / Universidade de São Paulo (Brazil)

COMITATO ORGANIZZATIVO

Francesco Stilo (Coordinator) / Università degli Studi 'Mediterranea' di Reggio Calabria
Vittoria Castiglione / Sapienza Università di Roma
Irene Cazzaro / Università di Bologna – Alma Mater Studiorum
Michela Ceracchi / Sapienza Università di Roma
Fabrizio Natta / Politecnico di Torino
Marta Pileri / Università degli Studi di Sassari
Lorella Pizzonia / Università degli Studi 'Mediterranea' di Reggio Calabria
Andrea Tomalini / Politecnico di Torino
Noemi Tomasella / Sapienza Università di Roma
María Belén Trivi / Sapienza Università di Roma

COMITATO DEI REVISORI

Alessio Altadonna / Università degli studi di Messina
Marinella Arena / Università degli Studi di 'Mediterranea' Reggio Calabria
Martina Attenni / Sapienza Università di Roma
Leonardo Baglioni / Sapienza Università di Roma
Alessandro Basso / Università degli Studi di Camerino
Laura Carlevaris / Sapienza Università di Roma
Lino Cabras / Università degli Studi di Sassari
Emanuela Chiavoni / Sapienza Università di Roma
Enrico Cicalò / Università degli Studi di Sassari
Luigi Cocchiarella / Politecnico di Milano
Daniele Colistra / Università degli Studi 'Mediterranea' di Reggio Calabria
Francesca Condorelli / Libera Università di Bolzano
Marco Fasolo / Sapienza Università di Roma
Francesca Fatta / Università degli Studi 'Mediterranea' di Reggio Calabria
Amedeo Ganciu / Università degli Studi di Sassari
Alessia Garozzo / Università degli Studi di Palermo
Fabrizio Gay / Università IUAV di Venezia
Elisabetta Caterina Giovannini / Politecnico di Torino
Marika Griffo / Sapienza Università di Roma
Elena Ippoliti / Sapienza Università di Roma
Francesco Maggio / Università degli Studi di Palermo
Matteo Flavio Mancini / Università degli Studi Roma Tre
Silvia Masserano / Università degli Studi di Udine
Domenico Mediati / Università degli Studi di 'Mediterranea' Reggio Calabria
Valeria Menchetelli / Università degli Studi di Perugia
Davide Mezzino / Politecnico di Torino
Maria Milano / Escola Superior de Artes e Design (Portugal)
Sara Morena / Università degli Studi di Palermo
Caterina Palestini / Università degli Studi di Pescara
Francesca Picchio / Università degli Studi di Pavia
Francesca Porfiri / Sapienza Università di Roma
Paola Raffa / Università degli Studi 'Mediterranea' di Reggio Calabria
Veronica Riavis / Università degli Studi di Udine
Jessica Romor / Sapienza Università di Roma
Daniele Rossi / Università degli Studi di Camerino
Anna Sanseverino / Università degli Studi di Napoli
Giovanna Spadafora / Università degli Studi Roma Tre
Roberta Spallone / Politecnico di Torino
Ilaria Trizio / CNR L'Aquila
Graziano Mario Valenti / Sapienza Università di Roma
Michele Valentino / Università degli Studi di Sassari
Starlight Vattano / Università degli Studi di Trento
Chiara Vernizzi / Università degli studi di Parma
Marco Vitali / Politecnico di Torino

Francesco Stilo, Vittoria Castiglione, Irene Cazzaro, Michela Ceracchi, Fabrizio Natta, Marta Pileri, Lorella Pizzonia, Andrea Tomalini, Noemi Tomasella (a cura di)
eXploЯA UID 2024
Virtual Journeys to discover inaccesible heritages
© PUBLICA, Alghero, 2024
ebook ISBN 978 88 99586 49 2
Pubblicazione e stampa Dicembre 2024

PUBLICA
Dipartimento di Architettura, Urbanistica e Design
Università degli Studi di Sassari
WWW.PUBLICAPRESS.IT

PVBLICA

eXploЯA UID 2024

Virtual Journeys to discover *in*accesible heritages

a cura di

Francesco Stilo
Vittoria Castiglione
Irene Cazzaro
Michela Ceracchi
Fabrizio Natta
Marta Pileri
Lorella Pizzonia
Andrea Tomalini
Noemi Tomasella
Maria Bélen Trivi

ISBN: 978 88 99586 49 2

风沙侵蚀
创想
我的
云游长城
Yun You Chang Cheng
Entre
百闻不如一见
Seeing is believing
探索
保护
创想
我的
18:05
答题识长
切磋知识，发
不知道的长城
明长城嘉峪关
探索
保护

Online Games as a Pathway to Elevate World Cultural Heritage Conservation in China

Ruitao Li[1], Xiaoxu Liang[2]

[1]Indipendent Scholar
[2]Department of Architecture and Design, Politecnico di Torino, Turin, ITALY

ruitao.li@studenti.polito.it; xiaoxu.liang@polito.it

Keywords: Online Games; Chinese World Cultural Heritage; Public Engagement; Cultural Heritage Conservation.

Abstract

Preserving the Great Wall, a renowned Chinese cultural heritage site, poses several challenges due to insufficient public awareness, inadequate policies, and a shortage of professional management staff. Urgent intervention through the integration of new technology is necessary to address these pressing issues. In recent years, the use of digital platforms and Extended Reality (XR) technology has emerged as a transformative force in the preservation and promotion of cultural heritage content. XR technology can make cultural heritage digitally accessible, providing users with an immersive experience and promoting public engagement. And thanks to the potential to engage communities, educate young people and present cultural heritage in digital formats, online games have become an important catalyst in the field of heritage conservation. Games offer a platform where players can learn through action, and education is cleverly integrated into the playful narrative rather than being explicitly stated beforehand. The integration of gaming, XR technology and digital tourism actively involves communities, surpasses physical constraints, and bridges the temporal gap between the past, present, and future.

In the year 2022, the China National Cultural Heritage Administration forged a collaborative partnership with Tencent Games, culminating in the creation of a WeChat [1] application christened Great Wall E-tour. This compact application package has been ingeniously designed to allow users to virtually travel the Great Wall and participate in its restoration, all through the medium of their mobile devices. Notably, the application also facilitates an immersive exploration of the "Digital Great Wall" while providing a profound insight into its historical lineage. Beyond mere exploration, it also encourages active engagement in the restoration process of this iconic monument. This study serves to underscore the pivotal role of Great Wall E-tour as a multifaceted World Heritage preservation tool in the specific context of China. The discourse here explores the significant contribution of online games, with a particular focus on the use of XR technology in the broader field of heritage preservation and promotion. It demonstrates the integration of XR technology in the context of museums, historic sites and educational initiatives. The article also highlights the critical importance of maintaining a seamless and immersive gaming experience while imparting knowledge about the past, underscoring the need for a harmonious balance between educational content and user engagement.

Fig. 1 - Overview of the Game Yun You Chang Cheng.

Introduction

Game-based learning has been confirmed as an efficient approach that can provide an engaging and interactive way, to educate the public about the significance of cultural heritage (CH) content conservation (Camuñas-García et al., 2023a, 2023b; Mortara et al., 2014; Varinlioglu & Halıcı, 2019). Extended Reality (XR) technology, covering Augmented Reality (AR), Virtual Reality (VR), as well as Mixed Reality (MR) technology (Fast-Berglund et al., 2018; Mudička & Kapica, 2023; Okanovic et al., 2022), can make CH sites digitally accessible regardless of time and space constraints, its character of the connection of virtuality and reality has enabled this technology to be widely used in CH area for education, virtual tourism, and preservation since the mid-2000s (Bekele et al., 2018). In recent years, researchers have increasingly focused on exploring the impact of combining XR technology and online games (OGs) to convey CH information, and have developed some XR serious games in this domain (Zhang et al., 2018, 2021; Ekonomou & Vosinakis, 2018; Vu et al., 2018).

The article explores the integration of XR technology in OGs, and its potential to engage communities in the preservation and promotion of CH in the Chinese context. It is structured as follows: Section 2 offers a comprehensive literature review on the role of OGs with XR technology in raising public awareness of CH content conservation and dissemination, providing a theoretical foundation for subsequent analysis. In Section 3, we examine the case study of the *Great Wall E-tour*, also known as *Yun You Chang Cheng* (YYCC) in Chinese, to illustrate how OGs can effectively enhance the aforementioned aspects and practically contribute to the expansion of the CH database within the Chinese context. Finally, the article discusses the current constraints in developing CH online games and proposes methods to mitigate them.

The role of OGs in CH conservation

OGs especially serious games have become a significant catalyst in the field of CH conservation. They have the potential to engage communities, educate young people, and present CH content in digital formats. This promising venture requires further analysis. Ordinary virtual tours only provide information, but online serious games enable the users to create their cognitive journey and gain a deeper historical understanding of CH content. They are instrumental in encouraging greater involvement of local residents in museums and CH sites pursuits, as well as archival processes, dealing with both tangible and intangible CH. Additionally, they also serve as a potent means of enhancing and communicating historical, cultural, and artistic heritage, transcending time and space restrictions (Champion, 2016).

Online serious games offer a unique opportunity for players to learn through action, with education cleverly integrated into the playful narrative rather than being explicitly stated beforehand. These types of games enable the public to learn about the importance of preserving cultural heritage in an engaging and interactive way (Camuñas-García

et al., 2023a). In light of this, global research has been conducted to focus on the development of online serious games for CH conservation. The Palazzo Madama Museum in Italy utilizes location-based mobile games to encourage young visitors to explore museums and participate in the process of creating meaning (Rubino et al., 2015). In Shiroishi, Japan, supporters of the computer game Sengoku BASARA are working to revive local tourism by showcasing their affection for their hometown (Yamamura, 2015). Similarly, Assassin's Creed Odyssey is a powerful tool for delving into the past, enabling players to explore places, understand changes, relive events, and gain insights into the lives, habits, and customs of people from historical periods (Cole, 2022). These games are a valuable pedagogical medium for preserving, representing, and sharing knowledge of CH (Varinlioglu et al., 2017). Then, with the successful application of XR technology in virtual museums, the researcher has confirmed online serious games using this technology have more advantages in the public engagement of CH (Ferdani et al., 2020). According to (Bozzelli et al., 2019), the combination of immersion and reality allows users a deep involvement on an emotional basis, and pay more attention to their experience within the 3D context.

XR online serious games on CH conservation and value promotion

XR online serious games enable worldwide users to access CH sites without temporal or spatial restrictions, further raising their interest and awareness on culture and history, through the 3D model reconstruction and representation of damaged heritages or unreachable sites. Various works showcase the diverse XR online serious games in the dissemination and conservation of CH assets. For instance, the *iMARECULTURE* project is designed with immersive technologies to make the unreachable underwater heritage site in the Mediterranean Sea accessible to the public through museums or the web, it includes a serious game for museum tourists to sail over the Mediterranean and an AR excavation game for divers. (Skarlatos et al., 2016). Varinlioglu and Halıcı (2019) proposed a low-budget treasure hunt game based on mobile phone for an archaeological site, to enhance visitors' interest, and promote the dissemination of CH contents through AR objects and trivia questions. Similarly, Mohammed et al. (2020) also proposed an audio AR online serious game to guide tourists to different attractions existing in the "JnanSbil" historical garden with stereo headphones, creating an interactive and immersive visit. Roumana et al. (2022) developed an educational 3D puzzle-like serious game to operate within a VR environment while aiming toward the dissemination of CH content to the younger public. XR online serious games enable players to experience culture and history through multiple senses, enhancing their enjoyment of cultural learning and interaction with CH content (Theodoropoulos & Antoniou, 2022).

In addition, XR online serious games have also demonstrated a positive impact on conveying knowledge about CH sites through reconstruction and representation

(Bozzelli et al., 2019; Varinlioglu & Halıcı, 2019). Kiourt et al. (2016) developed a comprehensive 3D virtual museum framework with dynamic capabilities, *DynaMus*, utilizing game engine software to provide CH content visualization and educational activities intertwined with VR technology. Hammady et al. (2016) combined indoor AR and gamification techniques in the Egyptian Museum in Cairo, for the sake of educating visitors about the history and the culture of ancient Egyptians. At the archaeological site of Delphi, Ekonomou and Vosinakis (2018) presented a mobile AR application *"Oracle of Delphi app"*, aiming to engage secondary school students in a playful exploration of the area, to discover the history of Delphi about the most significant monuments. Zhang et al. (2018) developed a VR serious game centered around the Terracotta Warriors culture tourism, encouraging visitors to actively explore Terracotta Army pits and the Mausoleum of the Qin Emperor, while also facilitating effective learning of the history and culture of the Qin Dynasty.

General information of OGs in previous literature is summarized in Tab. 1, which indicates that most XR online serious games are quizzes or at least include quizzes (Ekonomou & Vosinakis, 2018; Mohammed et al., 2020; Roumana et al., 2022; L. Zhang et al., 2018), puzzles (Roumana et al., 2022), treasure hunt (Ekonomou & Vosinakis, 2018; Mohammed et al., 2020; Varinlioglu & Halıcı, 2019), and excavation

Tab. 1 - General information of OGs in literature review.

Article Info.	Games	Genre	Game purpose	Target audience	Device	Site
Rubino et al., 2015	Gossip at palace	Location-Based	Educate	Young generation	Mobile phone	Museum
Yamamura, 2015	Sengoku BASARA	Action	Educate& Entertain	Local citizens	Computer/Mobile phone	Anywhere
Cole, 2022	Assasin's Creed Odyssey	Action role-playing	Educate & Entertain	Anyone	Computer/Video game consoles	Anywhere
Skarlatos et al., 2016	iMARECULTURE	Location-Based & Excavation	Educate & Research	Diver, visitor, Scholar	VR devices	Museum, Web
Varinlioglu & Halıcı, 2019	TeosGO	Treasure hunt	Educate	Visitors	Mobile devices	Archaeological site
Mohammed et al., 2020	No name	Scavenger hunt & Quiz	Educate	Visitors	Stereo headphones, Mobile phone	Historical site
Roumana et al., 2022	No name	3D Puzzle & Quiz	Educate	Young public	Computer, VR devices	Not mentioned
Kiourt et al., 2016	DynaMus	Simulation	Educate	Anyone	Computer	Web
Hammady et al., 2016	Horus	Shooting	Educate	Visitors	Museum digital devices	Museum
Ekonomou & Vosinakis, 2018	Oracle of Delphi app	Treasure hunt & Quiz	Educate	Secondary school students	Mobile phone	Archaeological site
Zhang et al., 2018	VR terracotta warriors culture-oriented travel game	Virtual visiting & Quiz	Educate & Value Disseminate	Visitors	VR devices	Museum

(Skarlatos et al., 2016), the playability of the games is relatively poor. Also, they have specific device or site of use requirements and stakeholders, for instance, some can only be played with head-worn devices (e.g. (Mohammed et al., 2020; Roumana et al., 2022; Skarlatos et al., 2016; L. Zhang et al., 2018), it is not friendly to users with motion sickness or not familiar with the equipment (Theodoropoulos & Antoniou, 2022). And most need to be played in conjunction with museums or archaeological site (Ekonomou & Vosinakis, 2018; Hammady et al., 2016; Mohammed et al., 2020; Rubino et al., 2015; Skarlatos et al., 2016; Varinlioglu & Halıcı, 2019; L. Zhang et al., 2018). Additionally, a majority of these games remain as artifacts for research (Ekonomou & Vosinakis, 2018; Zhang et al., 2018; Varinlioglu & Halıcı, 2019; Mohammed et al., 2020; Roumana et al., 2022), and they have rare opportunities to be released to the public (Camps-Ortueta et al., 2021).

Case study

As the largest single linear CH in the world, the Great Wall was listed as one of the World Heritage sites in 1987. However, due to long-term natural erosion and the primary material used (mainly rammed earth), most sections have collapsed or been damaged. According to the State Administration of Cultural Heritage of China, around 30% of the artificial walls of the Ming Great Wall have disappeared, and only 10% are well-conserved (People's Daily Online, 2021). Despite various sections of the Great Wall gradually being added to the key cultural relics under national protection since 1961, the current situation and protection work are still not optimistic. The 2017-2018 Report on the Conservation of the Great Wall indicated there is a lack of support for the protection and utilization of archaeological research on the Great Wall (Liu, et al., 2020). And the basic data measured has not yet been converted into the basis for the protection of the Great Wall (Zhang, 2018). In some regions, there is even a phenomenon of excessive use of technology (Cao et al., 2018). Furthermore, insufficient public understanding of the Great Wall's basic knowledge also makes it difficult to carry out further preservation. It is estimated that merely 40% of surrounding residents are aware of the Great Wall ruins in their living area (Zhang, 2018).

The Xifengkou Great Wall is one of the significant passes of the Ming Great Wall, located in Hebei province, which was also an essential transportation route at that time. Throughout history, this section of the Great Wall has suffered from problems such as the collapse and peeling of walls, because of long-term wars and frequent earthquakes. Furthermore, the construction of the Panjiakou Reservoir in the area has resulted in a portion of the Xifengkou Great Wall being submerged, creating a unique spectacle of the underwater Great Wall. In 2016, the Tencent Charity Foundation partnered with the China Cultural Relics Protection Foundation to collaborate with the Great Wall research teams at Peking University and Tianjin University, supporting the restoration of the Xifengkou Great Wall. During this process, they realized that CH protection

Fig. 1 - People Daily Online, *Screenshot of the Game Yun You Chang Cheng*, 2022 <https://cn.chinadaily.com.cn/a/202206/27/WS62b910e5a3101c3ee7adcccc.html> (last accessed Oct. 19, 2023).

requires not only physical restoration but also digital conservation. The elimination of time and space limitations, allows everyone to obtain the basic knowledge of the Great Wall.

To address these challenges, the National Cultural Heritage Administration partnered with Tencent Technology Public Welfare and Game Team to create the *WeChat* application YYCC in 2022 (see Fig. 1), drawing from their expertise and achievements in restoration work. Utilizing data collected from the Xifengkou Great Wall, the project encompasses the Great Wall E-tour game, educational modules on history, architecture, and protection, 360 degrees VR panoramic views of the Great Wall, and entertaining quizzes. In the game, users can experience the restoration work of the Great Wall, including archaeological cleaning, bricklaying, jointing, brick wall repair,

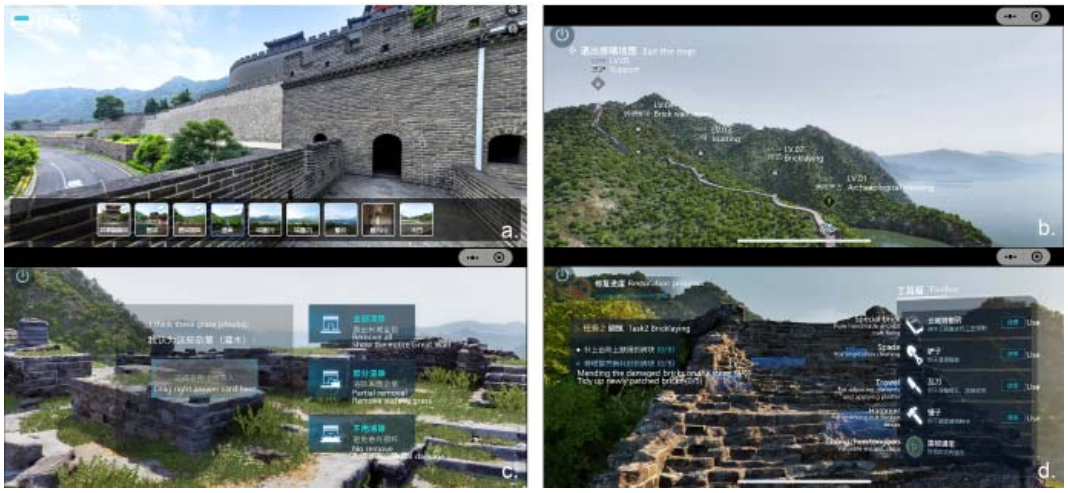

Fig. 2 - Yun You Chang Cheng, *The game contents of Yun You Chang Cheng (a. 360 degrees VR panoramic view; b. Restoration tasks; c. Quizzes; d. Game operation interface)*, 2022 <https://chiculture.org.hk/index.php/sc/school-program/the-great-wall> (last accessed Dec. 20, 2023).

and support. Through answering the quizzes, players can obtain specific tools for the accomplishment of the tasks, and they will learn the difficulties and approaches for the Great Wall restoration (see Fig. 2). Besides, thanks to the utilization of photogrammetry and Procedure Content Generation technologies and Unreal Engine 5, users can also take an immersive digital visit to the Great Wall simultaneously.

Due to the steep terrain of Xifengkou and its distance from the city, so much so that many people cannot easily access it. Through the high-precision restoration of these measured data, YYCC provides users with a complete natural environment, allowing them to experience the winter, summer, and day and night changes of the Xifengkou Great Wall immersively and freely. In addition, this project also includes 360 degrees VR panoramic cameras of other sections of the Great Wall, making users appreciate the scenery of the entire Great Wall to a great extent, regardless of the physical limitations. YYCC promotes online tourism of CH, which allows tourists who are unable to travel in person to visit the Great Wall at any time. It also encourages tourists to revisit and experience the Xifengkou Great Wall from various viewpoints at various periods, thereby increasing the popularity and mitigating the potential man-made destruction of CH assets.

Apart from its tourism function, YYCC contributes to the education of the Great Wall as well. It allows users to directly gain basic knowledge of the Great Wall, including its construction and defense system, etc. Through quizzes and repair tasks, users can have ideas on the factors that may cause damage to the Great Wall, and how to conduct protection and restoration. Additionally, relying on *WeChat* application and network operators (e.g. China Mobile, China Unicom, China Telecom, etc.), YYCC can collect and analyze the data on the user's age, geographic location, and the user's correct rate of quizzes to sort out the public's mastery of knowledge related to the Great Wall, and

then adjust and optimize the content of the game to better enable the public to obtain high-quality knowledge efficiently. Currently, YYCC has been used as a teaching case in primary and secondary schools in Hong Kong, increasing students' respect for the history of the Great Wall, and enriching their cultural knowledge.

Regarding the public engagement in the Great Wall conservation, YYCC adopts a first-person narrative and audio-visual content to enhance public emotional engagement and attract them to participate in game storylines, making players understand the significance and urgency of the Great Wall's restoration, and activate public empathy for heritage protection. Furthermore, users can get points through in-game repair tasks, daily quizzes, and reading learning materials. These points can then be converted into offline public welfare supplies to aid in the restoration and protection of the Great Wall. This method stimulates the public to be active learners, transforming their online participation into practical offline forces, and encouraging more people to participate in the protection of Chinese cultural heritage.

Besides, YYCC has also made some innovations in gaming technology. It is a mini program in WeChat based on mobile devices and webpage, using a cloud gaming transmission flow control algorithm, this technology can decrease time cost and operating pressure to ensure the quality of the users' experience under different networks. It will also be stationed in museums in the future, along the Great Wall in collaboration with the Great Wall Museum Association, to provide tourists with a more immersive and technologically advanced visiting experience. Additionally, it will serve as an innovative form of internet communication and carrier of digital technology, providing valuable reference for the future development and utilization of the global heritage sites as well as the digitization of CH.

YYCC has achieved significant success in developing innovative technology for measuring and visualising CH data. The application is a crucial tool for creating digital archives, not only for the Great Wall but also for measuring other various Chinese tangible heritage sites. YYCC has gathered precise measurement data for the Xifengkou Great Wall and its adjacent natural ecological environment using cutting-edge technologies, such as laser measurement and drone recording. The integration of these state-of-the-art technologies not only significantly reduces the labour and time costs associated with surveying, but also expands the digital database of the Great Wall. These methods for digital measurement and documentation provide robust support for future scientific research and creative digital representation of the Great Wall.

However, YYCC, a newly developed online serious game, exhibits areas that require improvement. Firstly, the project faces challenges associated with the absence of sustained funding investment. As a non-profit public welfare initiative, YYCC relies predominantly on charitable funds, a financial model that may struggle to adequately cover the substantial maintenance costs in later stages. Secondly, the game's simple mechanics primarily appeal to students, which limits its audience. For individuals with a certain level of pre-existing knowledge, the game's appeal may be insufficient.

Thirdly, the sustainability of interaction between the game and users is questionable, as users cannot revisit in-game restoration tasks, which restricts YYCC's functionality to digital exploration upon replay. Furthermore, the game lacks personalisation, requiring players to complete restoration tasks before gaining unrestricted access to explore the Xifengkou Great Wall. Players often follow prompts without engaging in critical thinking during restoration tasks, potentially leading to a loss of interest and minimal impact on enhancing public knowledge. Finally, the game only supports Simplified and Traditional Chinese, which can be challenging for non-native Chinese speakers and may hinder the global promotion of heritage value.

Discussion and conclusion

Online games for disseminating and educating on CH content in China are a recent development. Most existing games incorporate cultural heritage elements through temporary thematic events, (e.g. costumes of characters in *Arena of Valor* [2] and race maps in *QQ Speed* [3]). However, few games have been released to the public that not only reconstruct the history of CH but also convey information about heritage

Tab. 2 - Summarise of YYCC Contributions and Challenges.

Contribution	**Approaches**
Accessibility to heritage	3D modelling and visualisation
	Virtual museum
Heritage value promotion	Historical and Scientific Value
	Symbolic and Cultural Value
	Social Value
Education	Building process
	Culture knowledge
	History knowledge
Community engagement enhancing	Crowdsourcing data analysis for better user experience
Technology Innovation	High-precision measurement
	Virtual restoration
Digital archive	Data collection
	Measurement
	Visualisation
	Recording and dataset
Challenges	**Approaches**
Financial support and management	Involve broader communities (e.g. NGOs)
	Policy making
Limitation of users	Multilingual support
	Software usability
	User-centered approach
Sustainability of interaction	Personalisation users experience
	Raise public awareness of participation
	Improve the game's playability

value and conservation through edutainment. This article highlights the potential benefits of online games in promoting cultural heritage conservation in China, with a particular focus on the game YYCC. The contributions and challenges of the game for CH conservation is summarised in Tab. 2. However, it is important to note that there is a lack of evaluation of user experience, which requires further empirical research to address this limitation.

The integration of digital protection with cloud tourism in YYCC's heritage site gamification represents a significant advancement. This approach suggests a novel way to positively influence the reconstruction, preservation, education, and representation of cultural heritage content through online serious games. To enhance user engagement, the game employs a first-person narrative approach and incorporates audiovisual content, fostering an immersive learning experience. This is consistent with previous research (Mortara et al., 2014; Fenu & Pittarello, 2018; Lehto et al., 2020; Camuñas-García et al., 2023a). YYCC was piloted as a game design based on data from a partial section of the Great Wall site. It is advisable to broaden its implementation to encompass other sections of the Great Wall and potentially other world heritage sites.

However, a comparative analysis reveals that YYCC's game content is relatively simple and lacks customization, resulting in suboptimal gameplay. Furthermore, the game mainly targets primary and secondary school students, neglecting the user experience of the general public. Future initiatives should prioritize raising the game's playability and providing multilingual support to engage individuals from diverse backgrounds in CH conservation.

Despite YYCC employing an interactive reward mechanism to increase user interaction and enhance public awareness of participation in heritage asset conservation, the game remains largely object-centered rather than user-centered (Ch'ng et al., 2019). The article highlights the significance of interactive collaboration among professionals from different fields, such as educators, art directors, and game designers, for the success of a computer-human online serious game with a pedagogical objective (Mortara et al., 2014). It is recommended that future initiatives actively engage diverse communities or individuals in the development of CH online serious games. Authorities are urged to provide policy and financial assistance to support institutions and game development companies in this endeavour.

Notes

[1] *WeChat*, also known as *Weixin* in Chinese, is a multifaceted Chinese application developed by Tencent. It combines instant messaging and social media functions, similar to *WhatsApp* and *Instagram* respectively. It also supports numerous mini applications, making it a versatile digital experience for users.

[2] A multiplayer online battle arena game developed by TiMi Studio Group, Tencent Games, and Proxima Beta Pte. Limited.

[3] An online racing game developed by Jade Studio.

References

Bekele, M. K., Pierdicca, R., Frontoni, E., Malinverni, E. S., & Gain, J. (2018). A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. *Journal on Computing and Cultural Heritage, 11*(2), 7:1-7:36. https://doi.org/10.1145/3145534

Bozzelli, G., Raia, A., Ricciardi, S., De Nino, M., Barile, N., Perrella, M., Tramontano, M., Pagano, A., & Palombini, A. (2019). An integrated VR/AR framework for user-centric interactive experience of cultural heritage: The ArkaeVision project. *Digital Applications in Archaeology and Cultural Heritage, 15*, e00124. https://doi.org/10.1016/j.daach.2019.e00124

Camps-Ortueta, I., Deltell-Escolar, L., & Blasco-López, M.-F. (2021). New technology in Museums: AR and VR video games are coming. *Communication & Society*, 193-210. https://doi.org/10.15581/003.34.2.193-210

Camuñas-García, D., Cáceres-Reche, M. P., & Cambil-Hernández, M. D. L. E. (2023a). Maximizing Engagement with Cultural Heritage through Video Games. *Sustainability, 15*(3), 2350. https://doi.org/10.3390/su15032350

Camuñas-García, D., Cáceres-Reche, M. P., & Cambil-Hernández, M. D. L. E. (2023b). Mobile game-based learning in cultural heritage education: A bibliometric analysis. *Education + Training, 65*(2), 324-339. https://doi.org/10.1108/ET-06-2022-0247

Cao, M., Zhang, S., Zhao, J., & Hong, Y. (2018). The Current Status, Problems and Integration of the Protection and Inheritance of China's World Cultural Heritage in the Context of Digitalization. *IOP Conference Series: Earth and Environmental Science, 199*, 022061. https://doi.org/10.1088/1755-1315/199/2/022061

Champion, E. (2015). *Critical Gaming: Interactive History and Virtual Heritage*. Routlege. https://doi.org/10.4324/9781315574981

Ch'ng, E., Cai, S., Leow, F.-T., & Zhang, T. E. (2019). Adoption and use of emerging cultural technologies in China's museums. *Journal of Cultural Heritage, 37*, 170-180. https://doi.org/10.1016/j.culher.2018.11.016

Cole, R. (2022). Mashing Up History and Heritage in Assassin's Creed Odyssey. *Games and Culture, 17*(6), 915-928. https://doi.org/10.1177/15554120221115403

Ekonomou, T., & Vosinakis, S. (2018). MOBILE AUGMENTED REALITY GAMES AS AN ENGAGING TOOL FOR CULTURAL HERITAGE DISSEMINATION: A CASE STUDY. *Scientific Culture, 4*, 97-107. https://doi.org/10.5281/zenodo.1214569

Fast-Berglund, Å., Gong, L., & Li, D. (2018). Testing and validating Extended Reality (xR) technologies in manufacturing. P*rocedia Manufacturing, 25*, 31-38. https://doi.org/10.1016/j.promfg.2018.06.054

Fenu, C., & Pittarello, F. (2018). Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum. *International Journal of Human-Computer Studies, 114*, 20-35. https://doi.org/10.1016/j.ijhcs.2018.01.009

Ferdani, D., Fanini, B., Piccioli, M. C., Carboni, F., & Vigliarolo, P. (2020). 3D reconstruction and validation of historical background for immersive VR applications and games: The case study of the Forum of Augustus in Rome. *Journal of Cultural Heritage, 43*, 129-143. https://doi.org/10.1016/j.culher.2019.12.004

Hammady, R., Ma, M., & Temple, N. (2016). *Augmented Reality and Gamification in Heritage Museums*

(Vol. 9894, p. 187). https://doi.org/10.1007/978-3-319-45841-0_17

Kiourt, C., Koutsoudis, A., & Pavlidis, G. (2016). DynaMus: A fully dynamic 3D virtual museum framework. *Journal of Cultural Heritage, 22*, 984-991. https://doi.org/10.1016/j.culher.2016.06.007

Lehto, A., Luostarinen, N., & Kostia, P. (2020). Augmented Reality Gaming as a Tool for Subjectivizing Visitor Experience at Cultural Heritage Locations–Case Lights On! *Journal on Computing and Cultural Heritage, 13*(4). https://doi.org/10.1145/3415142

Liu, W., Xu, H., Feng, S., & Yu, B. (2020). 中国长城保护报告(2017-2018) [Chinese Conservation Report of the Great Wall (2017-2018). 中国文化遗产 *[Chinese Cultural Heritage], 02*, 91-102.

Mohammed, F., Azough, A., Kaghat, F.-Z., & Meknassi, M. (2020). *A Cultural Scavenger Hunt Serious Game Based on Audio Augmented Reality* (pp. 1-8). https://doi.org/10.1007/978-3-030-36653-7_1

Mortara, M., Catalano, C. E., Bellotti, F., Fiucci, G., Houry-Panchetti, M., & Petridis, P. (2014). Learning cultural heritage by serious games. *Journal of Cultural Heritage, 15*(3), 318-325. https://doi.org/10.1016/j.culher.2013.04.004

Mudička, Š., & Kapica, R. (2023). Digital Heritage, the Possibilities of Information Visualisation through Extended Reality Tools. *Heritage, 6*(1), art. 1. https://doi.org/10.3390/heritage6010006

Okanovic, V., Ivkovic-Kihic, I., Boskovic, D., Mijatovic, B., Prazina, I., Skaljo, E., & Rizvic, S. (2022). Interaction in eXtended Reality Applications for Cultural Heritage. *Applied Sciences, 12*(3), art. 3. https://doi.org/10.3390/app12031241

People's Daily Online (2021, September 13). 长城到底有多长? [How Long Is the Great Wall?] http://v.people.cn/n1/2021/0913/c440968-32225801.html. Last accessed Jan. 2, 2024.

Roumana, A., Georgopoulos, A., & Koutsoudis, A. (2022). DEVELOPING AN EDUCATIONAL CULTURAL HERITAGE 3D PUZZLE IN A VIRTUAL REALITY ENVIRONMENT. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIII-B2-2022*, 885-891. https://doi.org/10.5194/isprs-archives-XLIII-B2-2022-885-2022

Rubino, I., Barberis, C., Xhembulla, J., & Malnati, G. (2015). Integrating a Location-Based Mobile Game in the Museum Visit: Evaluating Visitors' Behaviour and Learning. J*ournal on Computing and Cultural Heritage, 8*(3), 1-18. https://doi.org/10.1145/2724723

Skarlatos, D., Agrafiotis, P., Balogh, T., Bruno, F., Castro, F., Petriaggi, B. D., Demesticha, S., Doulamis, A., Drap, P., Georgopoulos, A., Kikillos, F., Kyriakidis, P., Liarokapis, F., Poullis, C., & Rizvic, S. (2016). Project iMARECULTURE: Advanced VR, iMmersive Serious Games and Augmented REality as Tools to Raise Awareness and Access to European Underwater CULTURal heritagE. In M. Ioannides, E. Fink, A. Moropoulou, M. Hagedorn-Saupe, A. Fresa, G. Liestøl, V. Rajcic, & P. Grussenmeyer (Eds.), *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection* (pp. 805-813). Springer International Publishing. https://doi.org/10.1007/978-3-319-48496-9_64

Theodoropoulos, A., & Antoniou, A. (2022). VR Games in Cultural Heritage: A Systematic Review of the Emerging Fields of Virtual Reality and Culture Games. *Applied Sciences, 12*(17), art. 17. https://doi.org/10.3390/app12178476

Varinlioglu, G., Aslankan, A., Alankus, G., & Mura, G. (2017). R*aising Awareness for Digital Heritage through Serious Game – The Teos of Dionysos*. 647-654. https://doi.org/10.52842/conf.ecaade.2017.1.647

Varinlioglu, G., & Halıcı, S. (2019). *Gamification of Heritage through Augmented Reality* (p. 518). https://doi.org/10.5151/proceedings-ecaadesigradi2019_168

Vu, S., Cliburn, D., Helgren, J., Salyers, J., Canniff, K., Johnson, A., Milliken, M., Reardon, T., Sabbatino, K., & Stephan, A. (2018). Recreating Little Manila through a Virtual Reality Serious Game. *2018 3rd Digital Heritage International Congress (DigitalHERITAGE) Held Jointly with 2018 24th International Conference on Virtual Systems & Multimedia (VSMM 2018)*, 1-4. https://doi.org/10.1109/DigitalHeritage.2018.8810082

Yamamura, T. (2015). Revitalization of Historical Heritage Using Pop Culture in Japan: Shiroishi City and the Game/Anime Sengoku Basara. *Tourism Analysis, 20*(3), 327-332. https://doi.org/10.3727/108354215X14356694891933

Zhang, J., Zou, G., & Zhang, G. (2021). "Meet the Deer King": "Splash-Ink" Interaction in the Innovative VR Game Based on Dunhuang Art and Culture. *SIGGRAPH Asia 2021 XR*, 1-2. https://doi.org/10.1145/3478514.3487618

Zhang, L., Qi, W., Zhao, K., Wang, L., Tan, X., & Jiao, L. (2018). VR Games and the Dissemination of Cultural Heritage. In N. Streitz & S. Konomi (Eds.), *Distributed, Ambient and Pervasive Interactions: Understanding Humans* (pp. 439-451). Springer International Publishing. https://doi.org/10.1007/978-3-319-91125-0_35

Zhang, Y. (2018). 长城保护观念的困境 [The Conceptual Dilemma of Great Wall Conservation]. 建筑知识 *[Architectural Knowledge], 05*, 30-37.