Global Virtual Cultural Heritage Environment with attention to disability inclusion

A proposal for gamified immersive experiences of early watercraft and audience engagement

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Abstract: Early Watercraft (EW) all over the world marks the beginning of human migration, transportation, and shipbuilding traditions. Logboats, rafts, bark boats, and skin boats are among the oldest and most essential inventions of humankind, still used today by various indigenous cultures. Global existence suggests EW could be considered as one of the most exceptional universal cultural heritage despite being dispersed in diverse local and regional contexts around the world. Hence, more considerable attention should be given to this human achievement. In this paper, a new representation method for this dispersed and overlooked cultural heritage is proposed. For this purpose, a new paradigm scheme has been developed, connecting scattered scientific research with audience engagement focused on disability inclusion with Design for All principles. The proposal will be exemplified with two case studies from Slovenia, and Australia later tested with a digital geospatial platform, the *Early Watercraft Global Virtual Cultural Heritage Environment* (*EW GVCHE*). Since EW is a shared and inclusive heritage, it can serve as a bridge between different continents, countries and time zones, which allows the creation of a unique multi-user experience through immersive collaborative game design focused on availability, accessibility, and connectivity. Simple computer indie games inspire these low-cost and transferable solutions of short gamified Extended Reality (XR) experiences. Alongside the *EW* platform, the games will be accessed from various locations, including museums, interpretation centres, schools, and retirement villages as portable pop-up experiences. In Slovenia, a Late Mesolithic logboat from Hotiza will be used first to develop and test the proposed framework. In Australia, the framework will be further investigated in close collaboration with Indigenous Australians, the custodians of the local EW. The proposed approach is intended to be applicable to different dispersed heritage environments.

Keywords: *Early Watercraft—Extended Reality—Applied Games—Disability Inclusion—Accessibility*

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Introduction

Early watercraft (EW) can be considered as one of the earliest and most significant human inventions from technical, cultural, and environmental perspectives. The discovery that water—at the beginning rivers, lakes, and bays—can be utilized to improve human mobility represents an important historic milestone with a direct impact on human migration, navigation, trade, and infrastructure development.

“In fact, only three times in human history has man succeeded in leaving his natural habitat—dry land—and penetrating into other dimensions. On each occasion, a special ‘apparatus’ was required: first the boat, then the aircraft and finally the rocket.” (Ellmers, 1976 [1996])

The oldest archaeological material evidence, petroglyphs of reed-bundle boats from the UNESCO World Heritage Site in Quobustan, Azerbaijan (UNESCO, 2007), shows at least 13,000 years of use. Secondary evidence of migration 44,000–50,000 years ago argues that EW may have been used by Indigenous Australians when trading between Northern Australia and Asia (Arthur and Morphy, 2019). Moreover, through another evidence of migration, anthropological theory predicts the use of EW by Homo Erectus 850,000 years ago (Bednarik, 2014). Most of the EW, such as logboats, bundle-stem boats, skin boats, bark boats, and rafts, were made from organic material non-resistant to air and UV rays (Fig. 1). Hence, these artifacts have mainly been preserved in watery environments which caused that their research has always been a logistically complicated process. The lack of archaeological data in the last two centuries resulted in having only logboats being recognized as a significant cultural heritage.

The current permanent supplement taxonomy, which is being developed by the ambassadors of a global initiative Early Watercraft—A global perspective of invention and development (EWA), identifies more than 130 types (including original names) of EW worldwide. Even though EW has been well researched in many distinct scientific disciplines such as archaeology, anthropology, ethnology, Indigenous and living tradition studies, it remains relatively dispersed and hidden in local and regional stories. With the revival or continuation of practice by some of the local communities, the tradition of the everyday use of EW (see Fig. 1) is still alive in various parts of the world (Arnold, 2014; 2015; 2017; 2019).

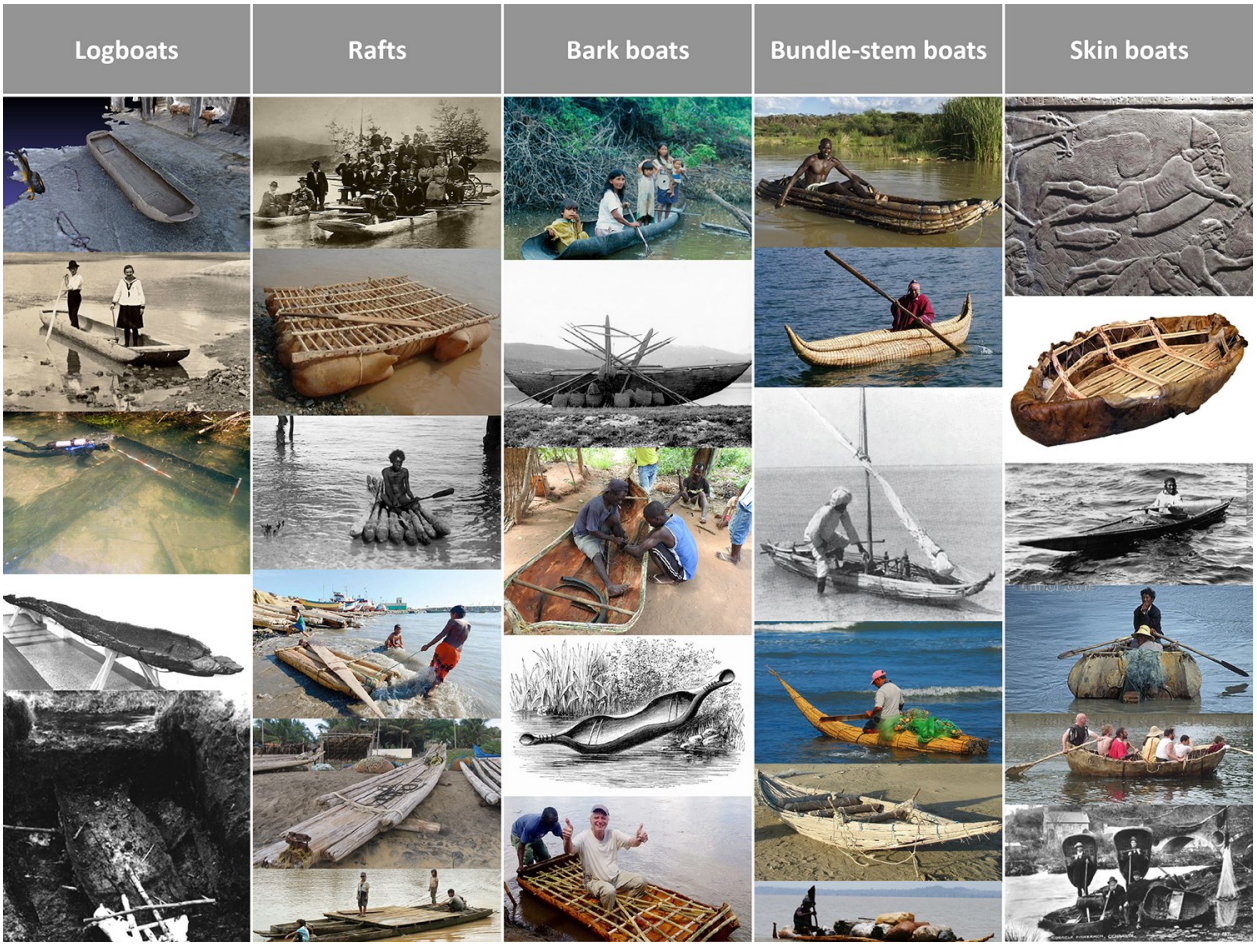

Fig. 1. An overview of different types of EW (Internet/Wikipedia search). ***Logboats****: © Gregor Berginc, © Miran Erič; © Stanko Ribnikar, © Aleksander Zgonc Collection; © Jože Hanc-Joc, © Skupina za podvodno arheologijo; © National Museum of Slovenia; © National Museum of Slovenia;* ***rafts****: © Ljoba Jenče Heritage House Cerknica; © Christine Tavernier; © Herbert Basedow (National Museum Australia Canbera); © Melissa Merino (La Republica); © Peter Malakoff; © Waldemar Ossowski;* ***bark boats****: © Beat Arnold, © Elton Rivas; © Mission Scientifique du Cap Horn; © Beat Arnold; © Beat Arnold, ©Mathews; © Beat Arnold;* ***bundle-steam boats****: © Ariadne Van Zanderbergen (APA Publication); © Andre Engels; © Ramin Adibi (Journal of Archaeology of Maritime Landscape Magazine); © Martin Garcia; © Ramin Adibi (Journal of Archaeology of Maritime Landscape Magazine); © Brian J. McMorrow;* ***skin boats****: © British Museum; © Anchorage Museum Association Acquisition Fund; © Samuel Herbert Coward (McCord Museum Montreal); © Direction Canada; © Simon Speed; © The Museum Collection of Cyngor.*

This proposed project addresses the issue of EW being often scattered in small, seemingly insignificant local heritage stories. A global virtual CH environmental approach developed in the last decade provides new challenges and opportunities on how to curate such dispersed heritage. Throughout recent years, a new CH paradigm and methodology to represent this extraordinary human invention through a virtual environment is being developed. Moreover, the latest development of modern underwater archaeology and sophisticated 3D digitalization tools have accelerated the interest of a wider heritage community in studying and digitally interpreting EW (Erič et al., 2013). However, a vast majority of scientific 3D digital/digitized assets and similar material stay in online heritage repositories accessible only to scholars. Such repositories have now matured to a stage where they became a rich and flexible virtual environment. Despite that, less complex and integral ways should be established to contextualize and communicate such resources for wider audiences.

An exceptional development of computer games in recent decades has enabled interactive history (Champion, 2015) in the form of applied or serious games, which are widely used in museums and schools. Moreover, the democratization of Extended Reality (XR), including Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR) and, 3D printed replicas/reconstructions, are shaping a new wave of digital heritage interpretation and audience engagement (Antlej et al., 2018a; 2018b). Immersive gamified experiences are thus becoming more suitable for heritage interpretation.

The proposed project intends to follow the well-known design approaches such as Design for All, Universal Design, and Human-Centered Design to ensure that the contents are accessible by broader audiences with different abilities. Special attention will be given to people with various impairments since this population is rapidly growing, among others due to the aging of society (Rebernik, 2019). Moreover, putting the needs of the most vulnerable heritage users, such as those with disabilities, elderly and other people with various impairments first, might also help to influence the way how technology is used for heritage representation and interpretation to enhance inclusion for all (Deffner et al., 2015). As scholars and practitioners have suggested (e.g. Hanson, 2004; Imrie, 2012; Rebernik et al., 2019), if the design is performed with the disability inclusion in mind, other users can also benefit from it. Universal Design or Design for All refer to services, products, and spaces (European Commission, 2015) and mean accessibility and inclusion for all. Human-Centered Design (HPIDSU, 2020) is a creative problem-solving philosophy focused on users, their needs and wants.

We selected in this article two case studies to discuss and develop a framework for communicating scientific data of both archaeological and anthropological/ethnological dispersed heritage in XR. First, XR experience gained in Slovenia with the interpretation of the seventh oldest known logboat worldwide from the Late Mesolithic (7,000–6,000 BC) found in the river Mura near Hotiza, will be further developed based on available scientific data and will be tested on end-users. Second, in Australia, a scientifically informed XR experience about living EW heritage will be developed and evaluated in collaboration with the local Indigenous community, the oldest living culture in the world. The combination of these two scientifically and culturally significant heritage cases has been carefully chosen to represent a broad spectrum of globally dispersed EW heritage content. As the logboat from Hotiza characterizes an archaeological artifact, Indigenous Australian EW is mostly in the domain of anthropological/ethnological research. In other words, the approach of how archaeological and living heritage is interpreted may vary. The two exceedingly different cases will assist in the development of a framework applicable across various EW objects. From a geographical perspective, regarding the local heritage audiences, the proposed cases cover two different continents on the Northern and Southern Hemispheres. This locational diversity provides challenges for accessing and experiencing “each other’s” dispersed heritage content as well as opportunities to investigate how to overcome such issues.

To address the identified challenges and opportunities, this article discusses a proposal to develop an engaging Global Virtual Cultural Heritage Environment (GVCHE) using EW as the study case with special attention to disability inclusion. Our research investigates the following questions:

- How can dispersed heritage of EW be connected globally not only from a scientific but also from a community engagement perspective?

- How can scientific 3D digital/digitized assets of EW be contextualized as a meaningful content to assist wider audiences to better engage with EW?
- How can gamified Extended Reality (XR) be used for creating engaging experiences for all, including people with diverse impairments?

A global network of Early Watercraft Heritage

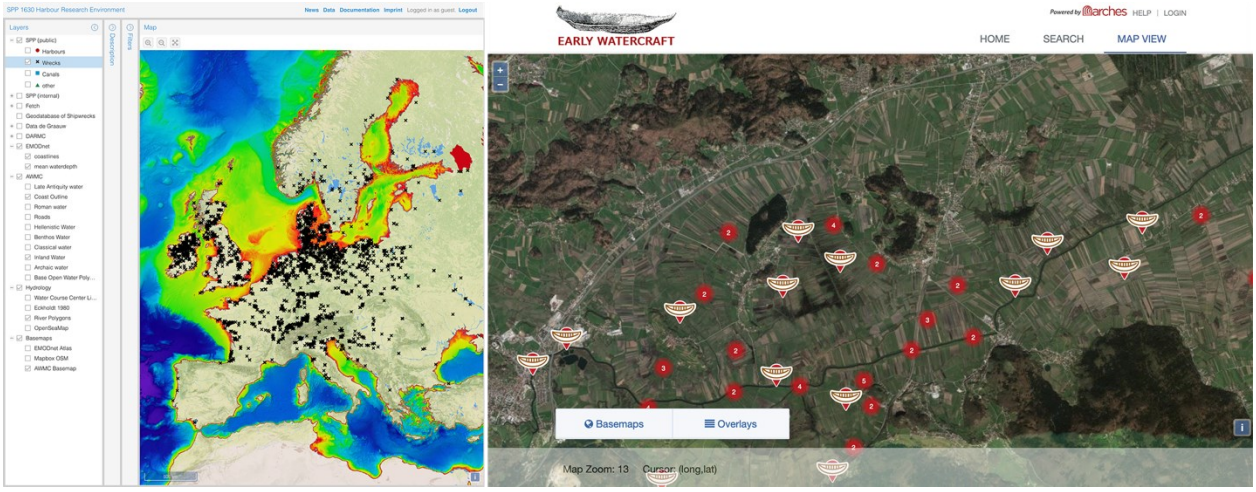

Fig. 2. Harbour Research Environment (HARE) of the SPP 1630 Harbours Program (left). Early Watercraft, a web repository showing logboats from Ljubljansko Barje. The first testing database was programmed on Arches V3.0 by © Bojan Kastelic, Computer Vision Laboratory, Faculty of Computer and Information Science, University of Ljubljana (right).

The proposal of the GVCHE presented in this article is based on the EWA Global initiative, which was inaugurated in 2015, in Vrhnika, a city in Slovenia, near one of the UNESCO World Heritage Sites – Prehistoric Pile Dwellings around the Alps (UNESCO, 2011; Erič, 2014). The EWA Global initiative aims to connect researchers interested in EW into a global network and to provide an open forum to geo-locate and exchange data, as well as to discuss strategies to recognize this type of dispersed heritage as a significant human achievement.

When this article was being written (May 2020), 109 individuals and 32 institutional Ambassadors from 53 countries from six continents were involved in the EWA network. The birth of the initiative coincided with Early Watercraft, a web-based geospatial information system published by the University of Ljubljana and the Institute for the Protection of Cultural Heritage of Slovenia.1 The platform runs on Arches (v3.0), an open-source data management system for heritage developed by the Getty Conservation Institute and World Monuments Fund.2 Currently, the EW platform (v1.0) includes detailed information on almost all known (92) logboats from Slovenia (Fig. 2, right). The platform is aiming to expand into a GVCHE to include the European database with almost 3,500 logboats (Fig. 2, left) recorded from the early 19th Century until today (Arnold 1995, 1996; Kröger 2018).

Each artifact in the EW includes not only its location, dating, condition, and related publications, but contains also visual materials such as data images and 3D models reconstructed either from

[1] www.earlywatercraft.org
[2] www.archesproject.org

archaeological drawings or from 3D digitalization. The EW platform is in principle targeting researchers and is therefore too elaborate for a wider audience with different abilities for learning and comprehension.

Disability inclusion in heritage

Heritage gives us a sense of belonging and identity. It touches the deepest parts of our human experience, which reaches beyond just fulfilling one's everyday routine. Hence, it is of paramount importance to make heritage accessible and inclusive to all. Accessibility and inclusion are, however, relative concepts. Accessibility can be perceived in broad terms of access and availability of spaces, services, products and information. In narrow terms, it can be perceived as a feature that responds to the needs of persons with disabilities. In more specific terms, one could think of physical accessibility (e.g. access to spaces), information-communication accessibility (e.g. access to media, books, lectures, websites, instructions, and notifications) or intellectual accessibility (e.g. making contents easy-to-read and spaces easy to navigate). Inclusion may be understood in broad terms (e.g. social, economic, and spatial inclusion) or narrow terms (e.g. disability inclusion, gender-based, age-based, and ethnicity-based) (Rebernik et al., 2014).

Herein we direct our focus onto exploring ways as of how to make cultural heritage accessible and inclusive to those people with diverse impairments and disabilities (Fig. 3, 4), for them to be able to enjoy it on an equal basis with others (UN General Assembly, 2007). Immersive digital technologies and tools nowadays offer countless opportunities to achieve this goal. Not only to reach beyond physical limitations of space, but also to create opportunities for making heritage accessible in ways concerning representation format and content even for sensory and intellectually impaired.

Virtual presence and distance accessibility, satellite connectivity, multimodality, and many more of the technological advances enable people with impairments to experience the world heritage beyond the traditional logic of materiality. A person in a wheelchair will be able to access physically inaccessible heritage in immersive ways from the comfort of their home. People with visual or hearing-impairment will get immersed through multisensory experience combining audio, visual, and haptic forms of content interpretation. Individuals with an intellectual impairment will learn about heritage through easy-to-understand contents, gamification, and visualizations (Pavlin et al., 2015). As we see, technology can help create a new inclusive paradigm where no one is left behind. However, there is still a long way to go, as the design is done by people for the people and thus requires strong partnerships with user-centered and audience engagement methodologies.

In the two presented case studies, we undertake an ongoing concern of the needs of people with physical, sensory and intellectual impairments, aiming at providing them with a unique global heritage experience in an accessible and engaging way. By partnering with people with disabilities and diverse experts on disability inclusion, digital accessibility, and inclusive education, and following guidelines such as Web Content Accessibility Guidelines (WCAG, 2018) standard, this research attempts to explore how to bridge the barriers that current heritage practices still predominantly impose on people with disabilities (see for example Rebernik, 2014; Riganti, 2017; Hayhoe, 2019).

Fig. 3. People with disabilities and an example of their interaction with heritage in a museum (© Nina Oman 2013) (Rebernik, 2014)

Fig. 4. People with disabilities and an example of their interaction with heritage in a museum (© Nataša Rebernik)

Gamified XR EXPERIENCES as a way to engage audiences with a GVCHE

Games in their basic form are a challenge or a scenario. They present the player with a challenge and “force” them to learn new skills and improve their abilities to solve the challenge. An immersive,

interactive, multimedia representation through which compelling problems are presented, invites the player to engage and make world-changing decisions (Gee, 2007).

Research studies show that an engaging, interactive experience fosters learning through self-sustaining cooperation, avoiding a 'Vegas Effect' (Dubbels, 2019) – learning that happens in games, stays in games, instead of being transferred to real life. Games enable learning through measured feedback by interacting with a game environment (Dubbels, 2019). Well-designed video games are intrinsically motivating (Malone, 1981; Dicheva et al., 2015). With immediate feedback, games implement a variety of optimal teaching and learning strategies (Gee, 2007), as well as encourage exploration and identification with virtual avatars in the pursuit of knowledge (Turkle, 1984; McCall, 2011). The repetitive nature of games allows players to experiment with different behaviors, modes of problem-solving, and interaction styles with complete safety (McDaniel and Vick, 2010). Users memorize information subconsciously because it is meaningful to the storyline, a subtle feature of the game, or a method of winning the game, resulting in an engaging experience, where learning emerges as a side effect (Malegiannaki and Daradoumis, 2017; Breuer and Bente, 2010). In the context of heritage, applied games, therefore, represent a valuable medium for learning through play.

In archaeological heritage, computer games have been used for a few decades. *Rome Reborn* initiative, launched in the mid-1990 by the UCLA Cultural Virtual Reality Laboratory, for example, deals with the reconstruction of Rome in the period around 320 AD through a series of apps and videos (Frischer et al., 2006). The latest version includes VR technology and is available for free at www.romereborn.org. A series of archeology-themed games *Excavate!* by Dig-it! Games enable players to learn about ancient civilizations through archeological research as one of the key game mechanics. The theme of Ancient Egypt is available for free at www.dig-itgames.com/excavate/. Another more recent example of an interactive VR experience is *Nefertari: Journey to Eternity,* also available at no cost on one of the biggest gaming platforms in the world—*Steam*. It allows a player to visit and explore Nefertari's tomb. Even in mainstream games such as *Assassin's Creed: Origins* and *Assassin's Creed: Odyssey* archeological and historical research took the lead in an educational game mode known as *Discovery tour*. This mode is similarly available on *Steam* separately from the main game. Additional recent examples are discussed by Lobinger and Hemker (2018), Bercigli (2018), and Aschauer et al. (2018).

For creating an engaging gamified heritage experience, it is vital to understand the concepts and elements behind entertaining commercial games. Gamification has already tried to achieve learning through entertainment. The term is usually defined as the use of selected game mechanics (points, badges, levels, leader boards, ranks, and rewards) in a non-game context to engage the users in an attempt to superimpose the stimulating motivational aspects of the game world onto the real world (Dicheva et al., 2015; Sharritt, 2010). However, positive feedback is merely a tool that provides structure and measures progress within a system (Bogost, 2013).

A gamified heritage experience should not only borrow a few selected elements of a game, but it has to be inclusive, enjoyable and tailored to the needs of target audiences. Hence, it is essential to examine the concept of personalized gameful design as well as the psychological and motivational factors present in most commercial games. Gameful design, first and foremost, considers the user experience before adding any game elements. The approach recommends to intentionally design

for gamefulness using game design thinking even when developing experiences in non-game environments. Instead of attaching game mechanics to various tasks in the experience, the tasks themselves are designed similar to games, without having to rely on external reward systems (Dicheva et al., 2015). Personalized gameful design (Tondello, 2019), known as adaptive gamification or tailored gamification, takes that concept one step further. This approach improves the user experience by allowing each user to have a different experience with the system, based on their individual preferences and abilities.

An immersive gamified experience should also provide value in function, emotion, and through playful interaction, encourage learning and social interaction (Dubbels, 2017). The psychological and motivational factors of an engaging and fun game experience can be broken down into four elements present in the principles of a few rather well-known motivational theories and models. Maslow's hierarchy of needs defines intrinsic motivators, such as autonomy, mastery, and purpose. On the other hand, self-determination theory asserts that people have innate psychological needs of competence, relatedness, and autonomy. The four elements are, therefore, the elements of *challenge*, *mastery*, *autonomy,* and one not yet mentioned, but in our case of the dispersed heritage of EW very critical—*socialization*. The easiest way to understand how the first three correlate to the concept of fun is through the flow theory, a well-known concept about way games work. This theory states that activities which are in the balance between difficulty and skill, create a state of flow that is motivational. Simply put, if the challenge is too difficult, the player can experience anxiety and frustration. On the other hand, if it's too easy, it becomes boring. The experience of flow is often described as a spontaneous joy while performing a task, an optimal state of being in which one experiences intense focus or concentration, merging of action and awareness, as well as a high sense of agency (Dicheva et al., 2015).

When building a gamified heritage experience, a number of key game elements are to be considered. One of the essential components is accumulative grading. This enables the player to be rewarded with "experience points" or "going to higher levels" after they complete a task. Visible status and progress, coupled with challenge-based learning tasks and clearly set goals, let the player and their co-players know exactly where they stand. Each goal is a learnable challenge, and with the increasing complexity of a game, retaining the flow and the range of difficulty options is not easy to design, especially when considering users with diverse intellectual and physical disabilities. The player choice component provides a sense of autonomy. A player can choose to work on their challenge at their own pace and level of proficiency. Last but not least, the freedom to fail is another element, where failure comes with no serious consequences attached, allows the player to redo the challenges as often as they want (Deterding, 2013; Tondello, 2019).

MMOs (Massively Multiplayer Online games) may potentially be a suitable type of game for a dispersed but mutual heritage such as EW. MMOs enable an inclusive social activity accessed on-location in the form of a co-located (Hochleitner et al., 2013) and co-operative play, available from home. A major advantage in creating an MMO is a relatively well-established EW community. However, building a new "gaming" community can pose a challenge. Communication being the most important component, the experience must include in-game communication (through audio, text, or live, if on location) and off-game communication through forums. Game mechanics based on co-operative gameplay typical for MMOs can create sociability when played with a friend, family

member, or someone else from another part of the world. Furthermore, the game also enables a larger amount of resources, easier challenges, additional rewards, unlocked achievements, extra experience points, and similar. A system that enables and encourages social interaction, without forcing it, is crucial for the positive game experience, even in a mainstream MMO.

Considering that our goal is to create an inclusive experience intended for a particular audience, knowledge of their direct experience is also of utmost importance. There are several blogs, review sites and hubs where disabled players share their experiences with gaming in general (http://www.abilitypowered.com/, http://www.brandoncole.net/, and https://geekygimp.com/about/ among others) and which also provide helpful insight when designing a gaming experience tailored to their needs and desires.

An extensive reference list breaking down different aspects on what inclusive, accessible game design should consider and implement into a disability-friendly gaming experience already exists and is available at http://gameaccessibilityguidelines.com/full-list/, which may assist our task, though no less demanding.

A PROPOSED SCHEME of a GVCHE

The introduced concept of a GVCHE embodies a global digital geospatial platform connecting scientific heritage data from various disciplines with audience engagement content. In order to validate the proposed model, a case of EW is used since methodologies, and findings of different disciplines are not well linked to provide a holistic understanding of the notion of EW as dispersed yet important heritage. A more cohesive paradigm of how to study and communicate dispersed heritage represents a complex challenge, which may only be overcome through interdisciplinary and cross-cultural collaboration.

GVCHE for EW is an extension of an existing scientific EW platform (Solina, 2018; Oblak et al., 2019). As presented in the scheme (Fig. 5), such complex repository of research documentation organized using CIDOC/CDI (International Committee for Documentation / Common Data Index) standards, can be used as a primal resource for digital heritage interpretation and other audio engagement deliverables. Depends on the required level and means of interactivity, XR experiences, applied games, and 3D printed replicas/reconstructions could be created based on 3D assets and other data across different heritage interpretation environments: on-site, off-site, and on-line. For example, AR experiences could augment heritage parks and living cultures in situ. On the other side, virtual museums using VR could be available on-demand on-line or in hybrid spaces, such as at museum exhibitions. Stakeholders who could utilize the scheme for audience engagement may be content providers, including GLAM (Galleries, Libraries, Archives, and Museums) and other heritage institutions. Based on their audience research results, they could create inclusive content for all in collaboration with tourism, educational, and community sectors. In addition to general audience engagement, GVCHE is intended to be a valuable resource and a sharing platform for scientific studies across various, even non-heritage disciplines, such as hydrology and geology. Traditional research outputs could enrich the scientific part of the platform. However, non-traditional could contribute to audience engagement endeavours also in the form of a franchise.

This framework for documenting and communicating dispersed heritage represents the basis for heritage preservation, and inclusive audience engagement, as well as for policy making and budget management. Particular segments could partially be understood as working packages or projects. In the next stage, smaller research projects may be developed to investigate different elements of the proposed scheme, including the two case study proposals, discussed in this paper.

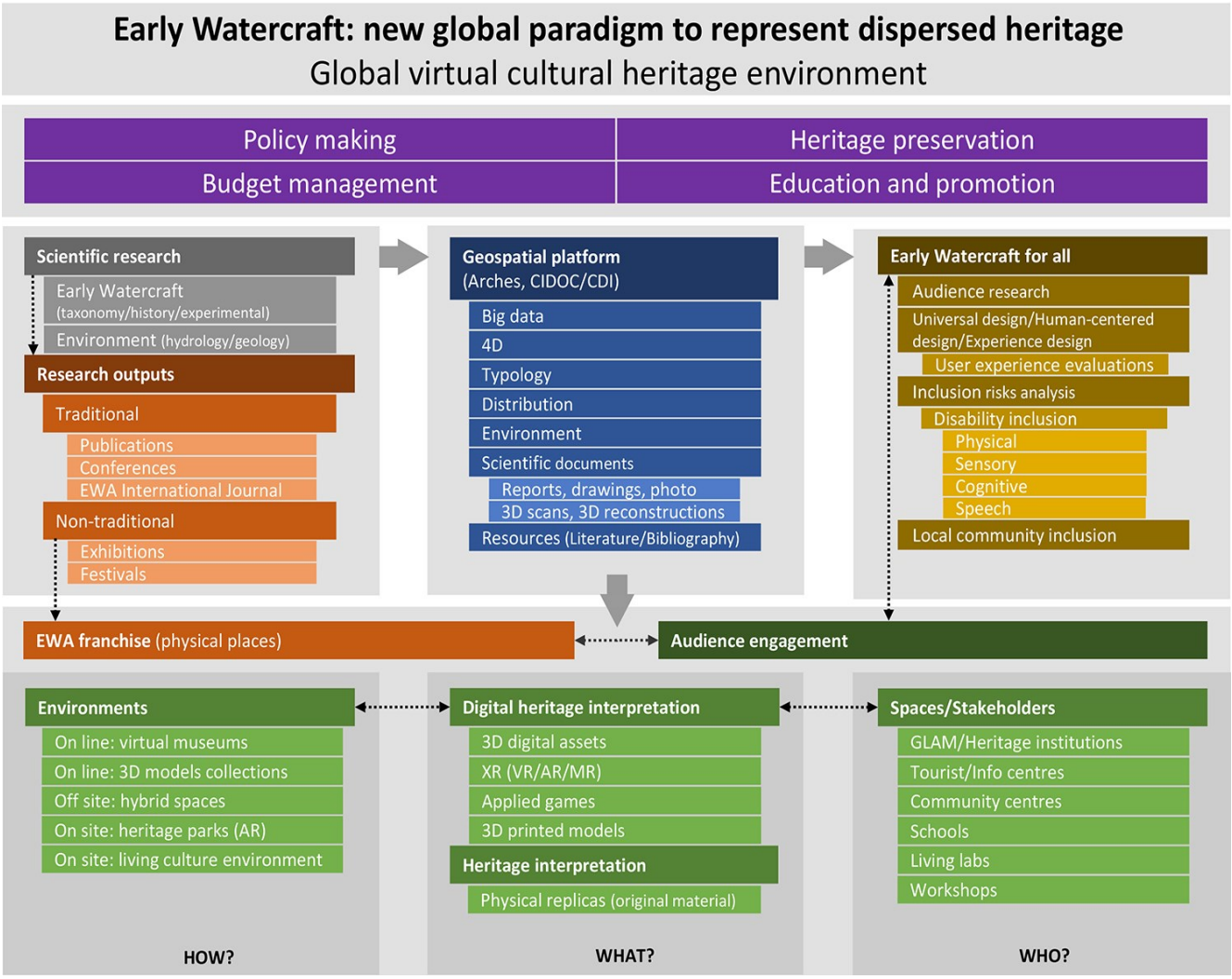

Fig. 5. A proposed scheme of a GVCH of EW

Case studies proposal: inclusive audience engagement with Early Watercraft

Since EW is a shared and inclusive heritage, it can serve as a bridge between different continents, countries, and time zones. In this context, dispersed heritage can be used as a testbed for creating a unique multi-user experience through immersive collaborative game design focused on availability, accessibility, and connectivity.

The proposed model contains the use of data images and/or 3D scanned assets as a scientific input for CAD (Computer-Aided Design) reconstructions. The 3D models are then texturized using available libraries to understand the material used in EW (wood log, skin, bark, stems, etc.) better. Once 3D CAD models combined with GIS (Geographic Information System) environment are created, polygonized 3D models can be generated for the use in XR. In order to develop an inclusive and

meaningful gamified experience, a user interaction with 3D assets must be well designed. These low-cost and transferable solutions of short gamified XR heritage experiences are inspired by indie games, a genre of simple computer games developed by independent authors. They can also be integrated into an MMO. Alongside the EW platform, the games will be accessed from various locations, including museums, interpretation centers, and schools as portable pop-up experiences. The framework will first be developed and tested using the two case studies in Slovenia and Australia. The framework aims to be applicable to other dispersed heritage content, too.

When considering inclusion and accessibility, the already mentioned extensive reference list with guidelines on disability-friendly gaming experience for diverse aspects of disability will help us face the challenging task of such highly interdisciplinary work.

The key feature of our design approach will base on adaptive experience which could be tailored on the spot to the needs of an individual user, even if part of a group. In practice, that means the ability to modify, not only difficulty of the game or controls (e.g. for diverse cognitive abilities), but also add/remove or rearrange specific on-screen features such as subtitles, interface size, color and font settings for color blind or visually impaired players and also adjust/change input method such as controller or keyboard/mouse binds.

The rule of two out of three will be pursued when creating XR experiences, meaning that all the information will be provided in at least two different forms out of three (visual, audio, haptic), which will enable accessibility also to those with visual or hearing impairment.

For intellectually impaired, the design will be such to be easy to comprehend, with the use of simple, clear language, narrative structure, tutorials, save game features and assist modes such as assisted steering or a co-pilot cooperative mode, where an able-bodied player can join in, as an alternative.

Some excellent solutions to be explored and incorporated into the platform for the two case studies will be as follows:

a) complete audio navigation for visually impaired; b) a complementary ALT-text for images; c) additional audio descriptions to all visualizations; d) videos with captions for deaf and hard of hearing; e) an easy-to-read content; f) gamification with easy-to-play options for intellectually impaired; g) opportunities for haptic experiences; h) inclusive storytelling as a part of heritage interpretation; i) inclusive and participatory pedagogic approaches. The core idea behind this holistically inclusive approach is the idea of Universal and Inclusive Design. That is, only when the needs of most vulnerable groups are addressed and the information is provided in multiple forms, everyone else will benefit from the experience, be it elderly, parents with children, temporarily injured, while fully-abled will benefit from enriched heritage experiences and multiple solutions to choose from.

The prototype will thus intend to incorporate all of the above elements within a simple experience of a building or riding an artifact. To illustrate, a potential scenario could engage users by accomplishing simple tasks such as transporting cargo and passengers (other players) while facing various environment-based challenges. Overcoming those challenges will be possible through direct co-operative play by a team of players, or a single player with indirect, optional help from an offline friend through various shared boosts, gained through simple knowledge-based side-quests such as quizzes, and multiple mini-games, tailored to a specific player and their needs.

Case 1: Late mesolithic logboat from Hotiza, Slovenia

In the first case, an EW archaeological artifact from Slovenia will be used. In 1989, in the gravel deposit of the river Mura near Hotiza, an oak logboat was found. Radiocarbon analyses date the vessel to the end of the 7th or beginning of the 6th millennium BC, which allows us to set it into the Late Mesolithic. It represents a find that is exceptional in its size, choice of wood, technological solutions, and, most importantly, its age (Erič and Nemec, 1993/94; Erič and Kavur, 2012).

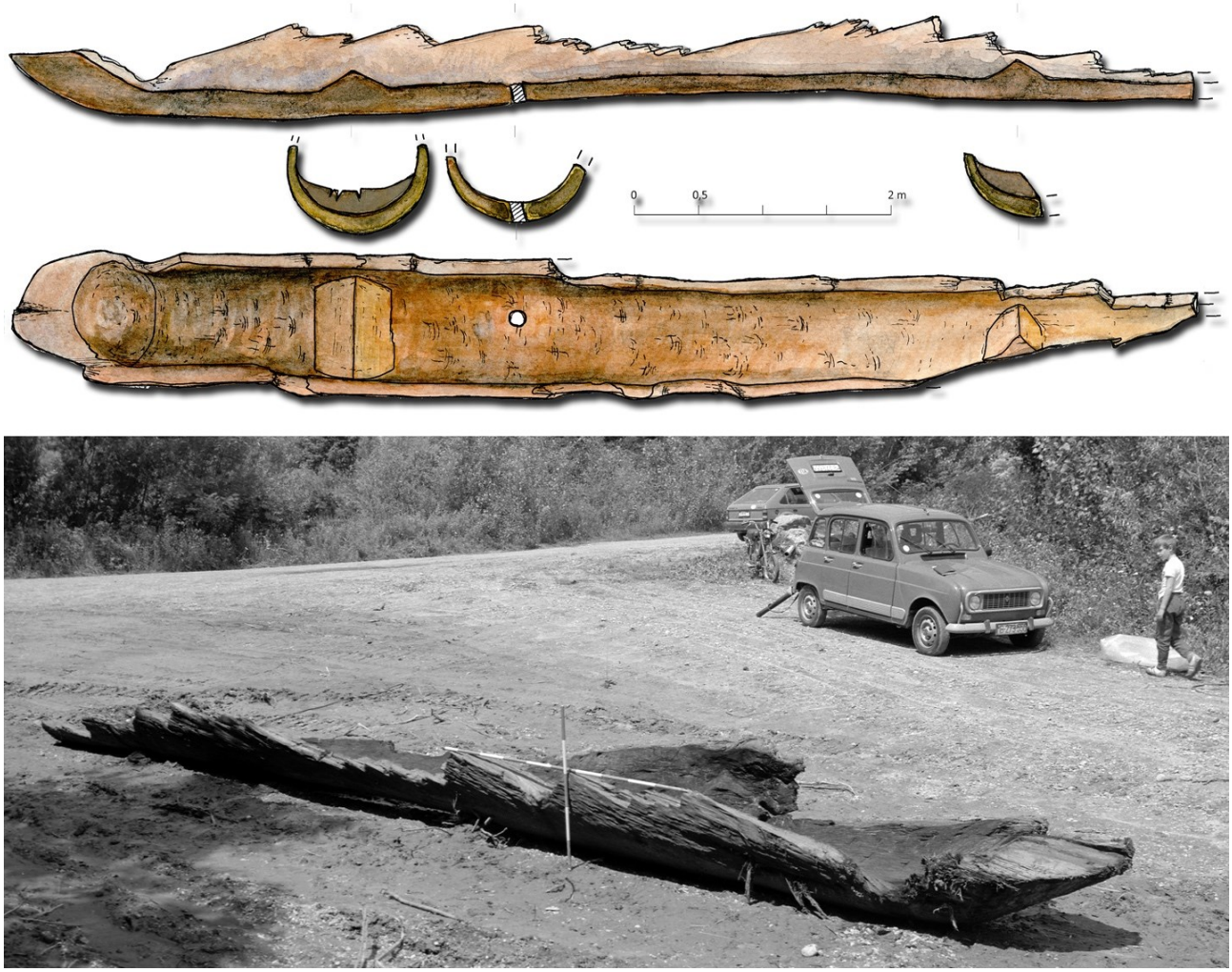

Fig. 6. Bottom: Examine of Hotiza logboat late June 1990 (© Ivan Tušek). Top: Colorised technical drawing of logboat (© Miha Erič based on the technical drawing made during site examine by Marija Lubšina Tušek in 1989)

The logboat was severely damaged, as it was repeatedly grabbed by a gravel basket, breaking part of the sides and part of the bow. The preserved length was 9.34 m, width up to 1.10 m and height up to 0.70 m. The average thickness of the bottom was 17 to 22 cm, and the sides gradually thinned from the bottom to the top, with an average width of 5 to 11 cm. About 5 m from the preserved forage, the trunk was concave in length, and the resulting negative gap was up to 15 cm high. About 2.5 m from the preserved feed, a transverse rib was constructed to strengthen the hull. The ribs were triangular in length, about 60 cm wide and 35 cm high at the bottom. In the cross-section, it adapted to the shape of the vessel and lifted towards the sides. A second, similar rib was made about 8 m from the preserved stern, but more than half were missing as

the boat was already severely damaged in this part. Approximately 4 m from the preserved feed, a 14 cm diameter round hole was drilled into which a softer wood plug was inserted (Fig. 6).

From the archaeological point of view, the logboat from Hotiza is, by itself, an isolated finding. It has less studying potential if we treat it without comparison to the other similar artifacts across Europe and the world within the same timeframe. As the logboat from Hotiza is the seventh oldest known in contrast to the other dated logboats around the globe (Erič, Lazar, and Stopinšek, 2017) – the only logical study which could be done is to compare its analysis to other logboats and types of EW.

Ten years later, in the early 2000s, when computer hardware, CAD and visualization software became more accessible, selected EW artifacts, such as the logboat from Hotiza, were re-documented in 3D for further study and communication. With the help of Art Rebel 9 (AR9),[3] a pioneering 3D visual communication company from Slovenia, a reconstruction of this logboat, as well as its original condition, was recreated as a 3D CAD model. Both models were further interpreted in a pre-rendered animation, displaying the change from the found condition to the virtual reconstruction in the time of use. A decade ago, texturization was very limited as computer-generated graphics were not as developed as today. Based on AR9's 3D documentation from a few years ago, the logboat from Hotiza has been recreated again by LaniXi DeviantArt, a firm for archaeological visualization (Fig. 7) together with drevak from Ljubljanica river basin e.g. Fig. 8).

This proposal aims to contextualize further the virtual 3D representation of the logboat from Hotiza as a gamified XR experience. The contextualization will use a storytelling approach. A background scene will be created based on cultural and geological scientific data about the environment when the logboat was in use.

Fig. 7. A preliminary (beta) 3D reconstruction of Hotiza logboat (© Lailan Jaklič – LaniXi art)

Case 2: Indigenous watercraft, Australia

The second proposed case study is focused on digital preservation and interpretation of the EW of Indigenous living cultures of the Australian continent and nearby islands. Indigenous Australia has the oldest living culture in the world. It comprises over 250 Language Groups (or Nations) and is dated as far back as 65,000 years (Langton, 2018). Each Nation should be considered as a separate country in its own right, run by different rituals, customs, and lore (Australian Government, 2020). As

[3] http://artrebel9.com

per the 2016 Census, 3.3 % of people in Australia identify as Indigenous Australians—the Torres Strait Islanders and the Aboriginal People (Markham and Biddle, 2018).

Fig. 8. Weddings on extended logboat drevak on Lake Cerknica, Slovenia (© Heritage House Cerknica [left]); A 3D model of an extended logboat (© Lailan Jaklič – LaniXi art [right]).

Indigenous beliefs stem from the values that we must coexist with the land, animals, and water. Sustainable living and interconnectedness are the foundation of the culture, and so when creating tools, food, or equipment, nothing would be wasted (Behrendt, 2015). The land was respected so much that smoking ceremonies and water blessing rituals would be conducted when welcoming people on to country, in order to provide spiritual protection over people and cleanse their spirit (Tribal Warrior, 2019).

Aboriginal and Torres Strait Islander culture was not written; all knowledge was passed down through story or song once a person was of the acceptable age and maturity level. The art in which these stories and knowledge were shared was called Songlines or Song Cycles, and as people grow or marry, so does their Songline (Horton, 1994). Indigenous technologies are still being discovered today due to colonizers overlooking Indigenous creativity, their knowledge of land management, as well as the hidden history within the Songlines.

As well as having the oldest living culture in the world, the Indigenous people of Australia are shown to be the first engineers of the world. The earliest relics of tools belong to the Indigenous Australians, and coincidentally the first evidence of intercontinental sea traveling (Arthur and Morphy, 2019). Researchers attempted to mimic the bamboo raft that traveled—most likely sailed—between Sahul (now known as Australia and Papua New Guinea) and Sunda (South-East Asia and Melanesia), using bamboo, oars, and sails. The approximate dates are assumed 44,000–50,000 years ago (Florek, 2012).

There is little information currently available predating the single and double outrigger canoes. As stated above, Indigenous people used the resources around them with no waste. Across Australia, Indigenous people used the materials at hand to create and build watercraft with the resources available to them (Arnold, 2015).

In the north of Australia, Arnhem Land, and the Cape York Peninsula, sewn bark canoes were used more than 3,000 years ago (Florek, 2012). Further along, in the Kimberley's and Western Australia, was the triangular log rafts typically made from mangrove trees. In Queensland, seafaring bark canoes were created at least 8,000 years ago. Victoria and New South Wales used bark canoes approximately 7,000 years ago (Florek, 2012). It was common for canoes to carry a fire that was protected by layers of sand within the boat to assist with navigation and resettling once the desired location was reached (Arthur and Morphy, 2019).

The Australian National Maritime Museum's (ANMM) Australian Register of Historic Vessels (ARHV) records several Indigenous watercraft and has a section 'Indigenous watercraft of Australia'. It provides an essential resource of all known types of Aboriginal and Torres Strait Islanders' watercraft (ANMM, 2018a). Curator David Payne argues these watercraft "could be living examples of the origins for the evolution for boats" (Payne, 2018). Until now, 46 types of watercraft from ANMM and museum collections across Australia have been registered with a photograph and other available relevant metadata (Fig. 9). Fourteen collection items have been mapped within the National Maritime Collection using the Getty Thesaurus of Geographic Names (TGN) based on their manufacturing or related place. The map is a useful resource for locating data. However, its purpose is mainly for reference only, rather a geographic information system with exact coordinates (ANMM, 2018b). Following the ARHV's listing of Indigenous watercraft of Australia, our case study intends to digitally interpret one or more recorded examples using gamified Extended Reality experiences. The main aim is to communicate Indigenous design and engineering heritage in a novel and inclusive way not only to younger generations of Indigenous and Non-Indigenous Australians but also to audiences overseas.

Due to its capability for storytelling, XR has the potential to become a widely used medium for communicating Indigenous knowledge. A relatively small number of artists, designers, and researchers have already started to explore XR. Virtual Songlines, founded by an Indigenous artist Brett Leavy, Bilbie Virtual Labs, is a great example of using new technologies to explore historical events or information. Virtual Songlines is a Virtual Reality simulation that has mapped known data of pre-colonization Australia landscapes. It allows a user to interact with the landscape and join in activities from Indigenous Australia, things such as hunting, foraging, corroboree, and canoeing.

Another example is Collisions, an 18-minute VR story directed by Lynette Wallworth. The film recorded as a 360-degree video features Martu Elder Nyarri Nyarri Morgan and his story about nuclear testing in his traditional lands in Western Australia. Among others, this artwork has been presented in various museums including ACMI (Australian Centre for the Moving Image) in Melbourne from the 7th of October 2016 to the 15th of January 2017 (ACMI, 2016) and at the Powerhouse Museum (MAAS – Museum of Applied Arts and Sciences) in Sydney from the 15th November 2019 to the 30th of June 2020 within the Linear exhibition (MAAS, 2019). Along with Collisions, the Linear exhibition features another XR experience. Interactive Wiyanga Bamulra Butt Butt Gurinyi (Mother Earth's heartbeat) utilizes AR on a provided tablet and virtual assistant (voice) in order to tell a personalized story about the object displayed. Users can interact with the exhibit through posting questions, which are then answered by a virtual avatar. The experience was created by Indigenous entrepreneur Mikaela Jade's Indigital in collaboration with Bilbie Virtual Labs.

Fig. 9. a. Kalwa. © Andrew Frolows (ANMM Collection 00001700); b. A Tasmanian ningher built by Sheldon Thomas in 2011, now on display at Melaleuca in Tasmania. © David Payne; c. Nawi, gumung derrka and ningher models. © David Payne; d. Paul Carriage from Ulladulla LALC brings an end together. © David Payne (Australian National Maritime Museum).

For providing a suitable framework for communicating Indigenous watercraft of Australia as gamified XR experiences, the project proposes the content to be publically available on the EW GVCHE platform via a localized digital Indigenous-led platform Our Songlines. The platform is designed to share Australian Indigenous culture with Indigenous and Non-Indigenous audiences to bring about understanding for the First Nations People. Our Songlines platform addresses the gap of limited information shared with wider audiences about the history of pre-colonization. The platform is an educational tool, which allows a person to view Indigenous sites, tours, and cultural business while also teaching users about culture and history. Our Songlines promotes Indigenous knowledge through images, maps, social media, and story. It is targeted towards the wanderlust, the educators, the truth seekers, and the adventure finders. There is a potential for the use of EW to shape a new adventure and share the education of the ingenuity of Indigenous Australians through the interactive map and XR experiences. It will be important to explore ways of representation of Songlines for people with diverse impairments. For instance, the interpretation of auditory stories to reach deaf and hard of hearing people will need to be given in visual, textual, and haptic forms. Whereas, intellectually impaired will benefit from textual and visual representations carrying an easy-to-comprehend story.

In the first stage, a set of interviews and focus groups with Indigenous communities will be conducted following relevant documents such as First Peoples: A Roadmap for Enhancing Indigenous Engagement in Museums and Galleries (AMGA, 2018), the Australian Indigenous Design Charter (AIDC, 2018), and similar. Ethical clearance will be sought as well following the National Statement on

Ethical Conduct in Human Research (NHMRC, 2007, updated 2018). The results will inform the decision which watercraft from the ANMM's Register of Indigenous watercraft of Australia is most suitable to be 3D digitized or 3D reconstructed for the first gamified XR prototype and what is the proposed scenario.

The XR prototype will later be developed and tested on user groups with various abilities, including Indigenous and Non-Indigenous museum visitors. In order to create jobs and a sense of belonging, it is planned to co-develop the experiences with the members of local Indigenous communities. Aboriginal and Torres Strait Islander designers and developers will primarily be invited to create the games. If required, training to upskill them may be established.

Our Songlines is an online platform that can partially feature Virtual Reality content on demand for users who own their own HMDs (Head-Mounted Displays) and supportive equipment. Besides, a mobile pop-up museum XR experience could be developed in a box to be easily transported to regional museums, schools, and community centers, as well as to hospitals and retirement villages to users with limited mobility. 3D printed props in a physical form of scaled EW digitized/digital reconstructions may be used, especially when addressing visually impaired users.

Discussion and Conclusions

The proposed project aims to investigate digital representations of dispersed heritage irrespective of its context and location as well as engaging opportunities for all, including people with diverse impairments. In this paper, a systematic approach for developing inclusive gamified immersive experiences from a publicly available scientific repository is proposed. The proposal will be tested on the EW GVCHE platform.

EW is one of the most important early technical human achievements mutual to all past and living cultures inhabiting near the water body worldwide. The proposal addresses the challenges and opportunities that this dispersed heritage faces to become more recognizable and unified on a global scale. Firstly, EW has been relatively well studied by various distinct scientific disciplines such as archaeology and anthropology/ethnology. However, instead of lacking joint effort, a more interdisciplinary and cooperative approach is needed to understand the holistic notion of EW. A collective forum for a shared discussion may be a valuable foundation. Secondly, EW projects are often limited to local initiatives, yet, more cross-cultural strategies may have a bigger impact on cohesion. Thirdly, a smooth knowledge transfer from science to wider audiences should be provided through actions of engagement to ensure science to stay relevant and for heritage to become a resource of empowerment and inspiration for future generations inclusive of all people.

The proposal of the geospatial digital platform GVCHE introduced herein is perceived as a holistic platform aiming at addressing these challenges. It aims to connect scattered scientific data from different disciplines. It represents an ambitious nexus between archaeology/anthropology, heritage, digital technologies, audience engagement, and disability. As such, it encapsulates a complex interdisciplinary approach, which already in itself brings multiple challenges. The success of the GVCHE will depend on many collaborators.

Furthermore, the GVCHE platform proposal explores ways of making the invisible and dispersed EW heritage noticeable. Even more, it may represent a valuable platform for reaching out to wider

audiences regardless of their (dis)abilities. Audience engagement strategies are proposed to be integrated into the GVCHE through the creation of non-scientific heritage content following principles analogous to Universal Design and Design for All. It is vital for all outreach activities to be tailored for users with different abilities rather than only consider the general public. When the needs of most vulnerable groups of people are addressed, everyone can benefit from any design, including heritage. Inclusive gamified XR experiences have been identified as a novel approach to the digital interpretation of dispersed heritage. Thus, relatively low-cost indie games in forms of XR experiences will be tested on two different cases: an archaeological artifact—a Late Mesolithic logboat from Hotiza in Slovenia, and Indigenous watercraft from Australia. The results of this research will represent a valuable study of how to communicate dispersed heritage to both scientific and non-scientific audiences inclusively. The finding may bring a useful methodological contribution to the digital interpretation of dispersed heritage.

To conclude, this proposed paradigm scheme represents not only a holistic but also a relatively complex research initiative. Anticipated challenges identified already in the proposal development are mainly related to interdisciplinary and cross-cultural collaboration as well as to technical limitations and funding resources. To minimize risks, a great deal of time is dedicated to building partnerships on various levels. In addition, the two proposed case studies provide a manageable terrain for initial investigation of the proposed framework from both technological and funding perspective before the suggested audience engagement strategy can fully be integrated into the GVCHE. Seed funding will first be sought before applying for larger grants.

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