Horizontes de la GESTIÓN CULTURAL

ISSN: 3061-8029
Vol. 6. Issue 11. January-June 2026

Master's Degree in Cultural Management and Development • CUAAD • University of Guadalajara

Virtual reality in conservation, preservation and dissemination of art: advances and perspectives.

La realidad virtual en la conservación, preservación y difusión del arte: avances y perspectivas.

Received: 06/10/2025 **Reviewed:** 23/11/2025 **Approved:** 03/12/2025

DOI: 10.32870/rhgc.e0030

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Abstract:
Virtual reality (VR) is described in this text as an innovative tool that contributes to the dissemination of art and the conservation and safeguarding of cultural heritage. In addition, it explains how VR is used to digitally protect heritage, create interactive experiences and facilitate access to cultural content. Three representative case studies are presented that examine the effectiveness of VR in restoring historical sites, protecting art, and generating immersive sensory experiences in museums. Furthermore, the ethical and technological challenges facing virtual reality in art are highlighted, and it is concluded that it has the potential to promote democratisation in access to culture, and that its application must guarantee the authenticity, accessibility and sustainability of digital experiences.

Keywords: Virtual reality, Immersive technologies, Digital conservation, Cultural heritage, Ethics, Art dissemination.

Resumen:
La realidad virtual (RV) en este texto se describe como un instrumento innovador que contribuye en la difusión del arte, en la conservación y salvaguarda del patrimonio cultural. Adicionalmente, se expone la manera que se emplea para proteger digitalmente el patrimonio, crear experiencias interactivas y facilitar el acceso a contenidos de carácter cultural. Se presentan tres casos de estudio representativos que examinan la efectividad de la RV en la restauración de lugares históricos, en proteger el arte y en generar experiencias sensoriales inmersivas en museos. Adicionalmente, se destacan los retos éticos y tecnológicos que enfrenta la realidad virtual en el arte; y se concluye que ésta tiene potencial para favorecer la democratización en el acceso a la cultura, y en su aplicación se debe garantizar la autenticidad, accesibilidad y sostenimiento de las experiencias digitales.

Palabras clave: Realidad virtual, Tecnologías inmersivas, Conservación digital, patrimonio cultural, Ética, Difusión del arte.

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Virtual reality

VR is a technology that allows the creation of computer-generated three-dimensional environments. In these spaces, users can interact in real time through devices such as headsets, haptic gloves, and controllers. VR is defined as an interactive, three-dimensional space in which users feel immersed and can also manipulate the environment in which they find themselves (Slater & Sánchez-Vives, 2016). Creating unique educational, sensory, and preservation experiences is something that can be achieved with VR and its environments, making it a potentially revolutionary tool for cultural management and heritage conservation.

For the physical preservation of heritage objects and sites, VR provides a virtual alternative to physical conservation and dissemination of cultural heritage, especially in cases where it is not possible to display them or interact with them directly (Cai, 2024). With 3D scanning and computer modelling, it has been possible to create digital replicas identical to the originals, allowing people to access them from anywhere in the world, facilitating access to this type of interaction.

Virtual reality (VR) is a significant tool for use in cultural expressions that require physical presence for their proper understanding and which, due to their tendency to disappear totally or partially, run the risk of losing connection with new generations. Torres Mas et al. (2022) highlight that the digitisation of heritage can serve as a means of safeguarding intangible cultural elements, providing new media for the multisensory interpretation of heritage. This can be seen in initiatives that reconstruct events with symbolic content that are representative of the many meanings of a given culture in virtual environments and can be accessed from mobile devices and virtual reality viewers.

When incorporated into the artistic sphere, virtual reality transforms the perception of the users who experience it. Dong and Cao (2022) mention that one of the most important characteristics of digital media is its interactivity, which can adequately compensate for the growing disparity between art and people through interaction with users, thus fostering greater integration between individuals and works of art.

Dong and Cao (2022) assert that virtual reality has transformed the arts by introducing users to immersive environments, simulating real-world scenarios, and reflecting real events. This allows users to experience new forms of art.

Consequently, as explained by Liu and Sutunyarak (2024), in the technology acceptance model in which they analysed the influence of immersion technology in museums on visitors' behavioural intentions, the results showed that perceived usefulness and ease of use significantly influence visitors' attitudes and satisfaction with immersive technology. As shown in Figures 1 and 2, the application of VR in the context of Mexico's cultural heritage could be, for example, at the Day of the Dead event in Pátzcuaro, Michoacán; Through VR, with work involving visual design, narrative, and accessibility of the virtual environment, people from anywhere in the world could experience the use of candles and marigold flowers, the creation of

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elaborate altars, rituals, and processions, with the participation of local community residents, as if they were there, to achieve an adequate appropriation of the cultural content.

Figure 1. *Virtual reality, Day of the Dead*

Note: Own work, Source: Open AI

Figure 2. *Virtual reality, Day of the Dead, Pátzcuaro*

Note: Own work, Source: Open AI

Immersive technologies in art and culture

Immersive technologies, including virtual reality (VR), augmented reality (AR) and mixed reality (MR), are emerging as catalysts for areas of opportunity in various fields. These technologies allow users to interact with three-dimensional virtual environments, producing sensory experiences that simulate physical presence in real or imaginary places.

Immersive technologies, especially VR and AR, transform the ways in which cultural and artistic expression is produced, mediated, preserved and accessed. These tools facilitate the construction of environments where users not only observe, but also actively explore, experience and interact, generating new ways of experiencing culture.

Transformation of the artistic experience

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The artistic experience is influenced by digital immersion in the context of the digital age. Grau (2003) states that new configurations of digital art transform the traditional way of perceiving it, allowing the viewer to enter the image and interact with it in real time, becoming part of the visual environment, while redefining artistic perception as a participatory and multisensory process. This way of experiencing art breaks with the passive attitude of the viewer, turning it into a more active dynamic of participation that requires the user to make decisions within the virtual environment. In this way, immersion redefines not only the aesthetic space, but also the process by which the cultural experience is produced.

Preservation and dissemination of cultural heritage

Immersive digitisation facilitates the conservation and projection of cultural heritage. According to Wang et al. (2024), "The integration of immersive technologies has transformed how cultural heritage is presented, enabling audiences to engage with it in a more vivid, intuitive, and interactive way" (p. 2). Furthermore, Angelidou et al. (2017) state that "the historical and cultural heritage of cities is and can be underpinned by means of smart city tools, solutions and applications" (p.27).

Physical interaction and cultural appropriation

The cultural experience with the application of VR benefits from achieving integration between the person's body and the interface. In this sense, Ma et al. (2023) highlight that with the technical support of artificial intelligence and human-computer interaction, the process of disseminating non-heritage culture based on embodied cognition theory can enable users to change from the traditional passive state of merely receiving information to a state where they can obtain the real experience of being in the virtual scene through different movements, gestures and other interactive behaviours. In their study on the traditional flower drum dance of Yicheng, it is demonstrated that virtual-real interaction helps to increase public interest, as it constructs experiences from the sensory and symbolic.

Ethical challenges of cultural immersion

It is important to mention that technologies must be used under strictly established ethical and technical criteria, in constant assessment and peer review by multidisciplinary experts, in order to avoid errors of interpretation or historical contextualisation. Tromp et al. (2025) consider that the design of a culturally immersive experience must consider the balance between usability, cultural authenticity and emotional engagement. From an ethical perspective, it is important to consider that virtual representations may simplify or generate stereotypes of a complex cultural reality. Furthermore, the use of these technologies must be considered in terms of equity; they must aim to be inclusive and accessible, not only to the average user, but also to those with different technical or cognitive abilities.

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The digital preservation of cultural heritage

Using digital technologies to preserve cultural heritage is a digital conservation strategy. Therefore, the digitisation of heritage objects and sites is only part of the creation of a visual replica, which is complemented by the preservation of their structural and sensory characteristics, for example in reconstructions reproduced in a digital medium, through virtual reality or augmented reality. Pereira Uzal (2023) argues in his doctoral thesis that the digitisation of cultural heritage must be of the highest quality in order to preserve its value and authenticity. This is a challenge for those involved in these processes.

The use of VR has implications for accessibility in itself, and now with the variable of heritage conservation, this variable further marks its growth. Peris and Sempere Ripoll (2024) argue that virtual reality as a metaverse "democratises access for all people by establishing a relationship in the digital space" (p. 145), adding that this technology "without physical or temporal barriers, expands opportunities for art in general" (p. 135). Digitisation should be seen as an expansion of the way cultural heritage is experienced and valued. Valuing cultural heritage and experiencing it in its form should be seen as an expansion of digitisation.

Interaction and educational mediation through VR

The application of VR in the educational context is also fundamental in the cultural field. Active participation by users in the exploration of art or heritage is due to the ability to create relevant interactive environments. This opens up a wide range of possibilities for creating personalised and profound experiences that promote interactive learning and the development of cognitive skills (Slater & Sánchez-Vives, 2016).

According to Ye et al. (2020), VR transforms traditional learning into a more dynamic and participatory experience, in which visitors are the creators of their own learning experience. For the reasons mentioned above, it is necessary to think about a context in which museums and cultural interpretation centres are involved in an interactive learning process, where users learn actively and reflectively, within the framework of understanding heritage.

The ethics of digital reproduction of heritage

Authenticity, cultural representation and intellectual property rights are factors that affect the digital reproduction of these elements of virtual reality from an ethical perspective. Questions arise as to who has the right to decide how a particular site or object can be represented and preserved digitally. To illustrate, Csoba DeHass et al. (2025) mention that projects focused on indigenous peoples face challenges related to indigenous digital heritage, the ethical use of their data, and ownership

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protocols, which underscores the need for frameworks that respect and defend indigenous rights and perspectives in the digital realm.

Rodríguez Pérez (2015) considered the Seville Principles in his master's thesis and, in addressing the principle of authenticity, stated that "Digitisation processes routinely work by reconstructing or recreating spaces, objects and situations from the past as they are believed to have been. [...] Authenticity must be a permanent operational concept for any heritage digitisation project" (p.173). On the other hand, Collin et al. (2019) state that thoughtful approaches are required for the collection, intentional construction of metadata, evaluation of ethical considerations, and appropriate presentation of digital heritage data for all.

For the above reasons, it is essential to include local communities and experts on the culture in question in the digitisation process, particularly in cases where history is complex or disputed. Therefore, cultural institutions and communities should be involved in the development of digital replicas in order to avoid the creation of incomplete or erroneous versions of heritage.

Challenges and limitations in the implementation of VR in cultural heritage

There are logistical and technical challenges to applying virtual reality in the context of cultural heritage. As mentioned by Krumpen et al. (2021), the costs associated with developing VR content, the need for specialised equipment, and the lack of trained personnel in cultural institutions are significant barriers to its widespread adoption. It is important to note that the application of VR requires high-performance devices to ensure an adequate experience, which is undoubtedly an obstacle to accessibility.

VR is important for the digital preservation of heritage, but from an ethical point of view, it is questionable whether these replicas offer the same meaning and emotional connection as the physical pieces or the original sites.

VR allows for the creation of immersive educational experiences and an innovative way to preserve heritage, but at the same time, it must take care to preserve the concept of authenticity, equity in access, and cultural representation.

VR is a collaborative process that must bring together the efforts of technologists, heritage communities and cultural institutions to ensure the digitisation of heritage in an inclusive, ethical and sustainable manner.

Case studies

The appropriation of VR in the field of culture has enabled the creation of projects with a significant impact on heritage and education. Below are three case studies that show how VR is being used innovatively in various areas of cultural management, demonstrating its flexibility for use in museum environments, historical reconstruction and art conservation.

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Case 1: Virtual reconstruction of Elmina Castle

Elmina Castle, located in Ghana, was declared a World Heritage Site by UNESCO in 1979. It was built in 1482 by the Portuguese. For more than five hundred years, it was a trading centre where European goods were exchanged for gold, ivory and slaves, and is considered one of the main centres of the slave trade in Africa. Its virtual reconstruction was carried out using large-scale laser-scanned point cloud technology and addressed two technical challenges. The first was the reconstruction algorithm to generate 3D models that could be rendered in real time with high quality on mobile virtual reality devices with limited resources. The second challenge was that the reconstruction algorithm had to be lightweight so that it would be accessible to the archaeological community in general. A low-polygon mesh was used, which significantly reduces the reconstruction and is the base representation of the scene. The details were transferred directly from the original point cloud to the mesh, which significantly speeds up reconstruction time and makes it easier for archaeologists and historians to reconstruct large heritage sites from huge point clouds using everyday computers (Ye et al., 2020).

This reconstruction demonstrates that it is possible to offer real-time rendering on mobile virtual reality devices with high visual quality, of complex architecture without the need for a high polygon mesh. The authors state that this project provides an immersive learning, research and educational experience for those who cannot visit it in person and represents a benchmark in the use of VR for heritage reconstruction (Ye et al, 2020). This case also provides conclusive evidence that virtual reality contributes to democratising access to heritage.

Case 2: Tactile and immersive heritage in European museums

Krumpen et al. (2021) developed a museum experience that combines VR with haptic feedback, allowing visitors not only to view but also to digitally "touch" heritage objects. The project consisted of scanning historical artefacts and replicating them using 3D printers, synchronising them with their virtual representation using tactile sensors.

The project was developed in museum spaces in Germany. The aim of this project was to offer multisensory experiences that promoted the inclusion of people with visual impairments and improved cognitive retention in school visits. "We focus on enriching VR-based object inspection by additional haptic feedback, thereby creating tangible cultural heritage experiences" (Krumpen et al., 2021, p. 1). The impact that these technological applications can have not only influences issues of accessibility, but also new ways of generating perceptions of heritage objects, closer to a direct and/or physical experience for the user.

Case 3. E-installation: Synesthetic documentation of media art using telepresence technologies

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E-installation is presented as a new method of synaesthetic documentation for the virtual recreation of multimedia works of art (Muñoz Morcillo et al., 2016). This method can be integrated into modern art conservation practices as a form of extended documentation within the framework of an information preservation strategy (Grau, 2000 cited by Muñoz Morcillo et al., 2016). In addition, it offers scalable access not only to curators, artists, conservators and art theorists, but also to art communicators and the general public. Likewise, the e-installation provides experts in 3D modelling and telepresence with a broad field of research on the thresholds of human perception, which influence the complexity and resolution of virtual recreation. (Muñoz Morcillo et al., 2016)

Furthermore, the same authors mention that, up to that point, two scenarios had been tested: Nam June Paik's video sculpture *Fountain of Versailles* and Marc Lee's net art installation *10,000 Cities in Motion: Same but Different*. In both scenarios, four steps were followed for technical execution: 1) creation of 3D objects in Blender; 2) use of sensor data; 3) integration of existing digital content; and 4) implementation of the logic of the art programme's ' '. The resulting application runs on a server that synthesises the sensory impressions of the artwork according to the user's location and perspective in a telepresence system (Muñoz Morcillo et al., 2016).

The project demonstrates how VR not only functions as a means of dissemination, but also as a method for the preservation of contemporary artistic practices, which could ensure their transmission to future generations.

Critical discussion

Based on the above analysis, it can be concluded that these three cases demonstrate that VR can be used to:

- Digitally preserve spaces and works at risk,
- Expand global access to cultural content,
- Offer participatory and sensory experiences, and
- Generate new models of exhibition and mediation.

Although the contexts were different, the three projects share a vision of integrating technology, narrative and heritage, reinforcing the importance of using VR as a strategy for cultural management.

The cases analysed also show significant achievements in terms of accessibility, immersive experience and digital preservation, which is why virtual reality raises new areas of conceptual, technical and ethical research and development in the processes of conservation and dissemination of culture. At the same time, VR has structural limitations that call into question its viability and universality.

Finding the balance between what is virtual and what is authentic is one of the main challenges of VR. In this context, VR can generate a false sense of presence in users, which does not necessarily mean that it complements the link with the

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object. Slater and Sánchez-Vives (2016) point out that sensory realism does not necessarily imply deep historical or aesthetic understanding.

Institutions with limited resources have significant inequality in access to technology such as VR. Benítez Miranda et al. (2025) state that "there are still inequalities in the adoption of these technologies, especially in countries with lower investment in digital educational infrastructure" (p. 5537); this has an impact on institutions, which face not only technical and economic barriers, but also training barriers to adopting this type of tool. For users in developing countries, access to devices such as viewers or haptic controllers is complicated in economic terms, which becomes a limitation because the corresponding user population represents a very large sector. As Krumpen et al. (2021) point out, the lack of specialised training in museums prevents many initiatives from moving beyond the pilot phase to stable integration within curatorial or educational strategies.

An important point is the question of who has the right to digitise a site or a work of art, as well as the implications of making free, virtual versions of these objects available. It is worth mentioning that in the case of Elmina Castle, digital reproduction involves describing an unfortunate episode in history, which may reinforce certain hegemonic discourses if local communities are not included in the digital stewardship process. On the other hand, the risk of technological obsolescence, changes in file formats, and dependence on commercial platforms jeopardise the long-term continuity of digitised works. For example, works that were originally developed in multimedia using Flash became obsolete and these resources were lost.

Furthermore, it is essential that VR transforms passive users into active participants in the cultural space, which is why it is worth making the effort to promote its use. Interactive, personalised and multisensory experiences enable new forms of learning and appropriation of cultural heritage.

However, it cannot be said that technology alone guarantees a meaningful educational experience, in comparison with analogue methods; it cannot be said that, no matter how much technology there is in cultural spaces, users will acquire more knowledge. In contrast, this depends on many factors, such as methodologies, so there must be one that balances VR with the strategy of cultural insertion, so that it is geared towards deep learning.

For the reasons mentioned above, VR and cultural management must be accompanied by:

- Ethical frameworks,
- Inclusive strategies,
- Commitment from institutions to a long-term sustainable process,
- A protective strategy, and
- Cultural methodology for deep learning.

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Conclusions

Virtual reality is a technological tool with enormous potential that can transform conservation processes and the dissemination of art and cultural heritage. The possibility of generating immersive, interactive, and multisensory experiences changes the paradigms of how users used to access this heritage and how they experienced culture, in search, of course, of being more inclusive, critical, and participatory.

In the cases examined, it is clear that this type of technology also permeates as an educational tool and a means of curatorial innovation. It should be made clear that technology can never and should never seek to replace heritage objects; it simply projects them in a different way to the user so that they can be used symbolically and pedagogically with the past.

The application of VR in cultural contexts requires adequate technology, training of staff in cultural institutions, and a deep and reflective process on the digital reproduction of heritage to avoid meaningless spectacularisation of what is reproduced. It cannot be said that VR is a universal or neutral solution, but it does have an essential impact since its introduction, based on cultural justice that is accessible, sustainable and participatory for the community.

It is important to note that the creation of projects focused on virtual reality requires interdisciplinary collaboration between different groups of technologists, researchers, conservators, curators, educators, and heritage communities. Based on the collaboration of these groups, it is possible to ensure that the reproduction of a heritage element does not become a decontextualised simulacrum, but rather a meaningful cultural experience for users.

Cultural institutions need to develop, either at the same time as or prior to this technological adoption, appropriate policies for the integration of VR, which, of course, include protocols for digital conservation, pedagogical strategies, and ethical frameworks for the reproduction of these cultural objects. Narrating, teaching, and preserving heritage in a digital form is the objective for which this technology should be used. The dilemma in terms of authenticity, ethics and accessibility are also challenges for policies and interdisciplinary collaborations, so once the appropriate balance between all these points has been achieved, we can talk about a tool that is truly inclusive and feasible in the field of cultural management.

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