VISUAL REVIEW | Vol. 17, No. 7, 2025 | ISSN 2695-9631
International Visual Culture Review / Revista Internacional de Cultura Visual
https://doi.org/10.62161/revvisual.v17.6056

FROM VR TO XR IN THE RECOVERY OF ARTISTIC HERITAGE

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KEYWORDS

Virtual Reality (VR)
Heritage Recovery
Extended Reality (ER)
Site-Specific Installations
Immersive Experiences
Contemporary Art
Mixed Reality

ABSTRACT

A principal contribution of this project is its evaluation of the application of virtual reality (VR) in the recovery of artistic heritage. VR constitutes an innovative tool that reshapes the manner in which viewers engage with artworks, providing computer-generated, three-dimensional environments in which users may observe and actively participate. The project has progressed towards the optimisation of VR, extending its application beyond heritage restoration to the creation of entirely virtual works, with the potential for future integration of artificial intelligence to enhance immersive artistic experiences.

Received: 30/ 06 /2025
Accepted: 01/ 10 /2025

1. Integration of Virtual Reality into the Conservation and Reinterpretation of Ephemeral Art Installations: An Interactive Labyrinth-Based Approach

The incorporation of virtual reality (VR) into the field of art installations represents a significant innovation in the exploration of space and sensory perception. *Virtual Maze* focuses on the virtual recreation of ephemeral installations, particularly those inspired by the structure of the labyrinth, a concept that symbolises the enigmatic and the transitory. Through VR, the project seeks not only to preserve these works but also to enrich their interactive and perceptual experience.

The study is based on the virtual reconstruction of three iconic installations: Mies van der Rohe's *Café Terciopelo y Seda*, Dan Graham's *Labyrinth*, and Carlos Cruz-Diez's *Laberinto de Transcromías*. VR offers new opportunities for the preservation and reinterpretation of these spaces, although it also poses challenges in the representation of materials, light, and transparency.

Unlike most VR experiences, which are essentially contemplative, this project adopts a more interactive approach, enabling the viewer to actively navigate through the work. In this sense, the reconstruction of the *Transchromatic Labyrinth* serves as a model for exploring the potential of VR in the conservation and evolution of ephemeral art installations, establishing new methodologies for its integration into contemporary art.

2. A Study on the Labyrinthine Experience and Spatial Perception

VIRTUAL MAZE (VM1) is an initiative designed to integrate virtual reality (VR) into creative processes related to art installations, particularly those inspired by the concept of the labyrinth. This notion originates in the Greek myth of Theseus and the Minotaur, where the labyrinth is conceived as a unique space, unlike any other known environment, serving as a boundary between the visible and the invisible, the evident and the concealed. Within the framework of this project, the labyrinth is explored as a creative catalyst in the conception of contemporary art installations.

The incorporation of VR as an immersive tool in the field of art installations represents a significant advancement. The ephemeral nature of installations, which are typically designed to be constructed and then dismantled, is counterbalanced by the potential of VR to preserve these works in the digital sphere, enabling their continued existence in an unaltered form.

The project focuses on the virtual reconstruction of ephemeral installations that, at their time, represented innovative approaches to materials, light, reflection and spatial experience. For the purposes of this study, three emblematic installations were selected: Mies van der Rohe's *Café Terciopelo y Seda*; Dan Graham's *Laberinto*, which links urban structure with the concept of the labyrinth; and the work of Carlos Cruz-Díez, who, through the use of colour and transparency, creates complex visual experiences that lead the viewer to become immersed in a chromatic labyrinth.

Unlike conventional artistic tools, VR enables a multiplicity of approaches to a single objective, offering new possibilities for creative and perceptual exploration. In this regard, the project approaches VR comprehensively, recognising the complexity of the technological processes it entails, including advanced programming and the use of specialised software, which are essential for achieving the intended outcomes.

The complexity of the project concerns not only the reinterpretation and reconstruction of the installations, but also the material challenges they pose, such as the treatment of translucent surfaces, reflective materials and the inherent behaviour of light. These elements represent technical difficulties that must be resolved throughout the project's development.

The adoption of VR as an expressive language enables the investigation of both the tangible aspects mentioned above and the conceptual transformation of the labyrinth as it shifts from the physical to the virtual realm. The technical demands associated with this transformation constitute one of the principal challenges of the research and are central to the project's design. Despite significant advances in VR technology, this field continues to offer vast potential for artistic exploration, in which elements such as viewer participation, colour, and transparency play a decisive role.

The project culminates in the virtual development of one of the installations under study, integrating the visual, mythological, and technical dimensions addressed in the research. The work selected for this purpose is Carlos Cruz-Diez's *Laberinto de Transcromías* (*Labyrinth of Transchromies*).

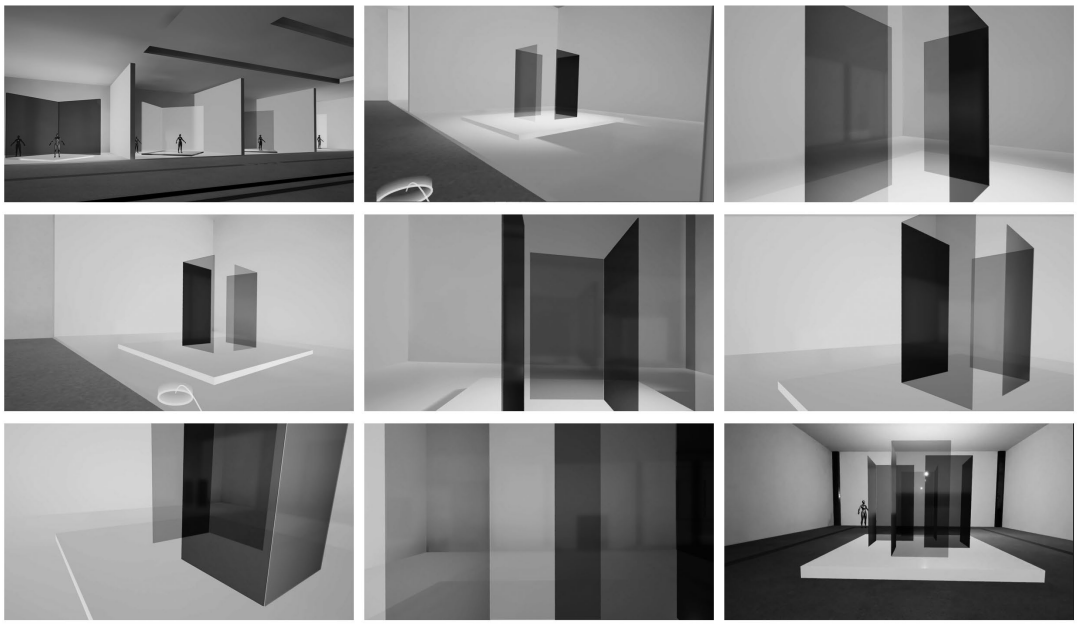
In the context of virtual reality, the fundamental characteristics required to create an effective virtual space are immersion, interaction, and imagination (Burdea and Coiffet, 2003; Grau, 2004). These

qualities are particularly evident in art installations based on labyrinthine structures, where the subjective experience of moving through space is essential (Lee, 2004; Slater, 2007). In VR, this sensation translates into a perception of the environment akin to that of a physical experience, allowing the viewer to move through the space in an immersive manner (Simó, 2019).

At present, most VR art installations remain primarily contemplative and demonstrative, without engaging the viewer in complex, participatory journeys such as those found in a maze. These experiences tend to replicate traditional artworks, merely adapted to VR technology, without significantly transforming the environment. This is the case in immersive exhibitions featuring artists such as Van Gogh, Klimt, and Sorolla. Although certain approaches introduce elements of interaction in virtual environments, such as immersive theatre (Machon, 2013) or virtual performances by artists like Marina Abramović, there remains a notable lack of sustained exploration of VR as a medium for constructing labyrinthine artistic spaces.

The present project seeks to investigate the creative potential of VR in the recreation of ephemeral art installations, focusing in particular on the virtual reconstruction of Carlos Cruz-Diez's *Laberinto de Transcromías* (*Labyrinth of Transchromies*). Through VR, the project aims to recreate not only the visual elements of the work but also its interaction with light and the viewer's perception, which are essential to preserving the essence of the original installation.

Figure 1. Initial approximation: transparency, scale and material tests. Image: *Virtual Maze*



Source: Authors elaboration, 2023

2.1. Methodology for Reproducing Art Installations in Virtual Reality: Technical Analysis and Optimisation in Material Simulation in Unreal Engine

A preliminary analysis of the installation of Cruz-Díez's work identifies several technical challenges in reproducing the work and the materials used. This detailed analysis highlights key factors that must be considered when transferring the work to a virtual reality environment, including:

Level of transparency
Level of reflection
Level of refraction

These aspects are fundamental for achieving a faithful reproduction of the work, given the nature of the system in which the installation is carried out. Virtual reality experiences and applications are systems that require a high degree of optimisation (Hsiang et al., 2021), particularly when striving to replicate a high level of realism. This requirement for optimisation is decisive in the selection of methodology and tools used during the recreation process.

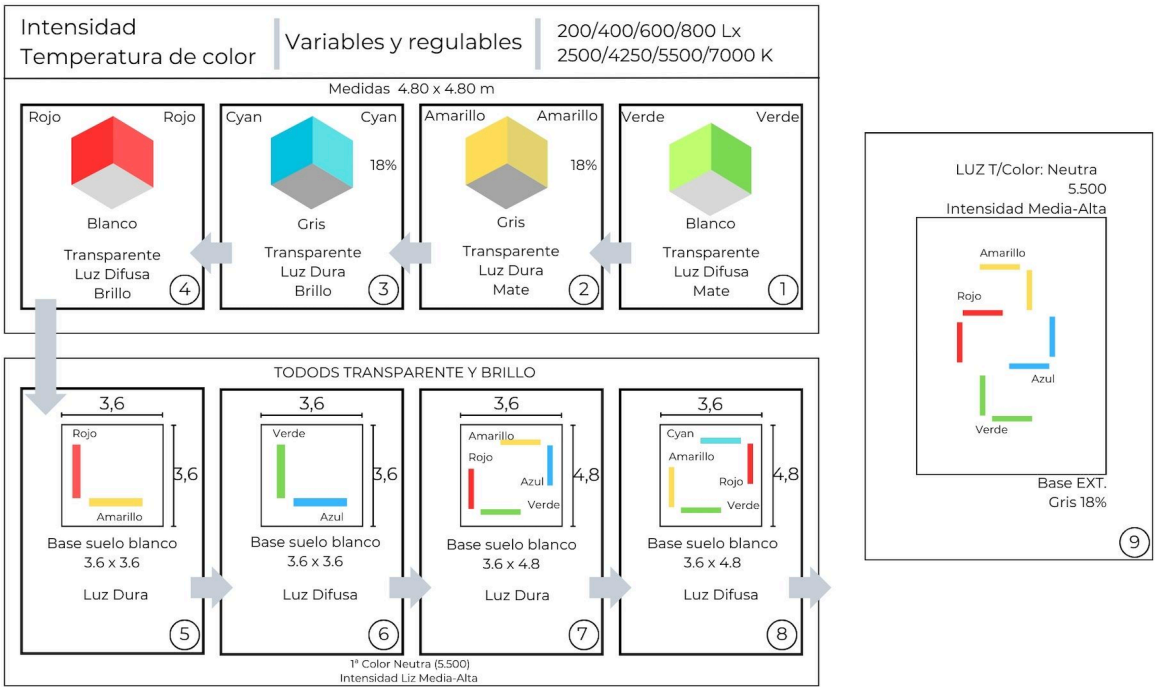
The platform selected for reproducing the experience is Meta Quest 2, a system employing Inside-Out pose tracking. The primary advantage of these systems is their ability to function without external

sensors or cameras to delimit the work area. Given the importance of realism in this installation, the Quest 2 system was connected to a computer via cable. Although this approach may restrict the user's movements within the experience, it significantly improves texture compression and transparency levels compared with the mobile Quest 2 system.

The platform chosen for creating the experience is Unreal Engine (Epic Games, 2023), version 5.1.1. This graphics engine is notable for its ability to generate a high degree of realism in the creation of materials and the lighting of environments, making it ideal for the development of virtual scouting systems (Kadner, 2019) and installations of this type. The initial experience is based on a standard VR project with teleportation mechanics implemented. This allows the user to move freely, either autonomously or using the Quest 2 controller. The teleportation option also enables the creation of scenarios that exceed the physical area available for the virtual reality installation.

Before reproducing Cruz-Díez's work, a base scene is established with different sets of test materials. These sets are used to experiment with the light, transparency, reflection, and refraction properties of the materials. They enable testing of Unreal Engine's native materials to identify those that most closely achieve the level of realism required for the reproduction. The Unreal Engine material system employs the Physically Based Rendering (PBR) workflow, which simulates the physical response of real materials within the rendering system (Pharr et al., 2016). Within this framework, variables are defined to evaluate the effectiveness and realism of the different materials in each experimental set.

Figure 2. Variable scheme for the experiment based on *Laberinto de Transcromías* by Carlos Cruz-Díez



Source: Authors elaboration, 2023

Table 1. Focus on greyscale

Parametre PBR	Data
Metallic	0
Specular	1
Roughness	0
Opacity	0.1
Refraction	1

Source: Authors elaboration, 2023

Table 2. Parameters and properties of the experiment

Property	PBR parameter
Transparency	Opacity
Reflection	Roughness Specular o Metallic
Refraction	Refraction
Tin	Color

Source: Authors elaboration, 2023

Based on the critical elements identified in the initial analysis of Cruz-Díez's work, a direct relationship is established between the parameters of the PBR material and the properties noted. This correlation of variables is employed to compare the different experimental sets. Among the shading models available in PBR for defining the physical behaviour of materials, the Thin Translucent model is selected. This model provides the greatest number of adjustable parameters, enabling a more precise reproduction of the physical behaviour of a material such as the glass used in Cruz-Díez's installation.

Table 3. Parameters and properties of the experiment

Property	PBR parameter
Transparency	Opacity
Reflection	Roughness
	Specular or Metallic
Refraction	Refraction
Tint	Colour

Source: Authors elaboration, 2025

Once various materials have been analysed using combinations of these variables and subjected to different lighting conditions, a detailed virtual installation of Cruz-Díez's work is developed. The objective at this stage is to apply the results obtained from the experimental sets. The final installation reproduces four dihedrals, each featuring a different colour, under the lighting and environmental conditions planned for the complete installation. In Unreal Engine, material parameters are measured on a decimal scale from 0 to 1, where 0 indicates the total absence of the property on the material's surface and 1 indicates its maximum intensity. The final parameters used to reproduce the glass of the dihedrals are configured as follows:

Table 4. Final parameters for replicating the glass properties of the dihedrals

PBR parameter	Data
Metallic	0
Specular	1
Roughness	0
Opacity	0.1
Refraction	1

Source: Authors elaboration, 2025

Finally, Adobe Substance Painter tools (Adobe, 2021) are used to create the textures of the base materials, corresponding to the environmental conditions of the room, such as the floor and walls.

2.2. Evaluation of Virtual Reality and Extended Reality in the Recreation of Art Installations: Analysis of Interaction, Materiality, and Immersion In Virtual Maze

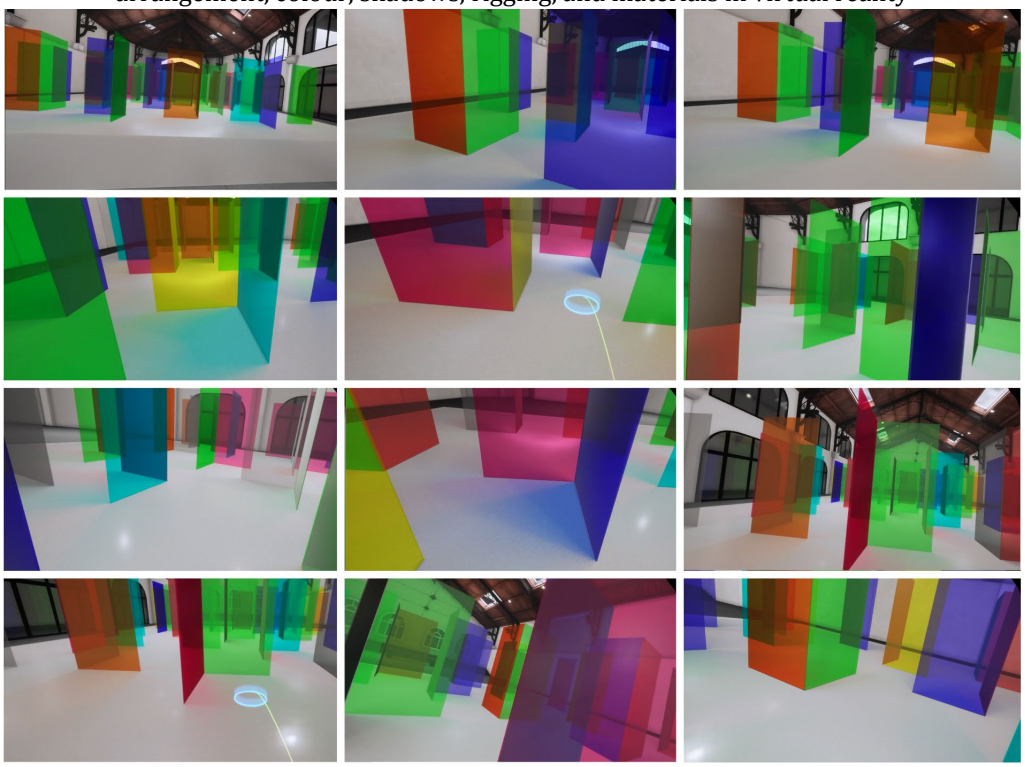
Virtual Reality (VR) was regarded as an effective tool for recreating spaces, routes, and the materiality of art installations, enabling, albeit with certain limitations, meaningful interaction between viewers and virtual human figures. The technical results achieved were faithful to the original work, supported by specific data collected from observers, which contributed to the advancement of the project. This

success was grounded in thorough research into the documentation and materials required for the recreation of site-specific art installations (Ramos Fabra and Pesqueira Calvo, 2023).

A notable development in the project was a shift towards extended reality (XR), a more suitable approach for this type of experience, as it permitted a more seamless integration of virtual and real elements, thereby overcoming some of the interaction and realism limitations of VR.

Experiments conducted in *Virtual Maze 1.0* (VR) and *Virtual Maze 2.0* (mixed reality) examined the refinement of the exhibition environment initially proposed in *Virtual Maze 1.0*. It was found that the VR-based experience tended to diverge from the intended sensation of total immersion, as the spatial definition surrounding the work distorted the perceptual effect sought in the maze of colours.

Figure 3. Recreation of *Laberinto de Transcromías* by Carlos Cruz-Díez. Tests of transparency, spatial arrangement, colour, shadows, rigging, and materials in virtual reality



Source: Authors elaboration, 2023

To this end, the technical methodology was modified, shifting towards extended reality as described below.

3. Development and Implementation of Phase Two: Optimisation of Materials, Immersion, and Spatial Experience in XR

Within the extended reality (XR) domain, which encompasses devices capable of reproducing virtual reality (VR), augmented reality (AR), and mixed reality (MR) experiences, a crucial distinction exists in the mode of immersion experienced by users of the installation. On the virtuality continuum (Milgram and Kishino, 1994), VR represents one extreme, where immersion is achieved through isolation in a wholly digital environment, as exemplified by the first *Virtual Maze* experience. At the opposite end of this continuum lies AR, in which the immersive component centres on the integration of digital objects within the real-world setting (Komianos, 2022).

Mixed reality occupies an intermediate position, combining elements of both extremes and offering an experience in which immersion arises not only from observation but also from interaction with a digital universe fused with real-world elements (Innocente et al., 2023; Mosadegh et al., 2024). This distinctive feature of integrating digital objects into reality necessitates a different approach to designing the installation compared with the previous version, which operated entirely within a digital environment, i.e., in virtual reality.

The most significant change begins with the selection of a different head-mounted display (HMD) than that used in the *Virtual Maze* installation. This choice follows best practices for implementing XR

technologies in immersive environments (Komianos, 2022; Mosadegh et al., 2024). In this case, the Meta Quest 3 was selected, enabling experiences in both virtual reality and mixed reality.

Improvements in the image capture and camera-tracking systems of this inside-out device allow mixed reality experiences with six degrees of freedom (6-DOF) (Annabestani et al., 2024). This concept refers to the user's ability to move freely along all axes of space, which is essential for achieving immersion in the maze.

This freedom of movement represents a second significant change from the previous installation. The HMD now operates without being physically tethered to a PC, markedly enhancing the sense of presence within the maze (Averbukh, 2014). Standalone operation introduces new technical requirements for the mixed reality project, as the responsibility for 3D surface rendering shifts from a computer's graphics card to the capabilities of the Meta Quest 3.

Although the Meta Quest 3 offers substantial improvements over its predecessor, the Meta Quest 2, and the device used in the original *Virtual Maze* installation, operating under standalone conditions necessitates careful graphical optimisation of the installation.

In view of these requirements, the first step in designing the new installation is to analyse the physical space in which it will be located. The proposed installation is a scaled-down version of the VR adaptation of Cruz-Díez's work, to be situated in the lobby of the Communication building at Francisco de Vitoria University. Considering the dimensions of the original installation and the available space, the new version occupies a rectangle measuring 12 metres by 4 metres. This reduces the 25 dihedrals of the original maze to 16, thereby adapting the work to the available environment.

The mixed reality component does not require abandoning the entire virtual environment that constituted the exhibition hall. This approach is advantageous in terms of optimisation, as the system needs only to render the dihedrals. Additionally, a floor object is incorporated to accommodate the dihedrals, replacing the real floor to enhance visual appearance and increase the sense of immersion. The floor texture is designed to replicate the original as closely as possible, thereby intensifying the feeling of presence within the installation.

Once the new physical characteristics of the 3D elements have been defined, the installation is optimised by reviewing the critical parameters of the VR version and integrating new elements, including:

Material transparency level
Material reflection level
Material refraction level
Lighting of the installation
Optimisation of shadows and reflections in the environment
Mixed reality tracking system

Version 5.3 of the Unreal Engine video game engine was employed for the development of this installation, selected for the enhancements it provides for mixed reality projects. This approach aligns with current recommendations for optimising rendering in XR environments (Komianos, 2022). Following this methodology, PBR (Physically Based Rendering) materials were implemented in the workflow (McDermott, 2018).

During the initial implementation using materials created for VR, a problem was identified with the shader in standalone mode on the HMD device: transparency and reflection lacked realism. Consequently, the shaders for transparent materials were optimised by switching from the Thin Translucent model to the Lit model with a Translucent blending mode, using the following parameters:

Table 5. Transparency and reflection parameters for the optimisation of transparent material shaders

PBR parameter	Data
Metallic	0
Specular	0.2
Roughness	0.5
Opacity	0.1
Refraction	1.52

Source: Authors elaboration, 2025

This optimisation reduces internal reflections on glass surfaces while substantially enhancing the realism required for correct operation in standalone mode. To compensate for the loss of dynamic reflections, these are pre-calculated and incorporated into the surfaces as part of their textures.

Regarding lighting, a diffuse system was designed to harmonise with the variable conditions of the real environment, combining diffuse natural light with a single point source of artificial light from the ceiling. The absence of additional point lights prevents defined shadows on the digital floor, ensuring even illumination of the dihedrals and adaptation to the real environment. Shadows and reflections between surfaces, such as the dihedrals and the floor, are pre-calculated and applied as textures to achieve a realistic visual appearance without compromising device performance.

User movement is facilitated with six degrees of freedom (6-DOF), enhancing the sense of presence and realism in XR experiences (Mosadegh et al., 2024). The Meta Quest 3 provides a free-movement mode which, in mixed reality applications, allows the user to visualise the real space through the HMD, thereby minimising the risk of collisions. However, the uniformity of the exhibition environment, comprising white walls and glass surfaces, impaired the tracking performance of the camera system. To address this, non-fiducial markers of varying shapes and colours were placed on the walls, improving the system's ability to adjust accurately to the designated space.

For future phases of the research, several areas for improvement were identified. The tour should be physical, rather than purely virtual, to enable a more realistic perception of space, considering that the Oculus 2 system could facilitate greater freedom of movement. Additionally, the aim was to make the tour interactive, allowing viewers to perceive their own reflection in the glass and to engage simultaneously with other participants, thereby achieving full immersion.

Although aspects relating to materials, such as colour, transparency, reflection, and refraction, were adequately realised in the VR recreation, further refinement was deemed possible. The dual nature of light, as both particle and wave, offered a wide range of combinations affecting the materials, which needed to be explored to achieve enhanced realism.

While VR provided near-total immersion, allowing for precise understanding of spatial geometry and materiality, there was a risk that the complete transformation of real space into a virtual environment could dilute the conceptual integrity of the art installation. Consequently, the integration of extended reality, combining virtual and real environments, was considered.

The ultimate objective was to establish criteria for the use of VR and ER as tools in the creative development of art installations, thereby expanding opportunities for interaction and experimentation within the field.

3.1. Assessment of the Impact of Mixed Reality on Art Installations: Technical Development, User Interaction, and Perception in XR

New mixed reality (MR) configurations applied to immersive installations have optimised the user experience by integrating digital and physical elements, thereby overcoming the limitations of entirely isolated virtual reality environments. The implementation of the Meta Quest 3, with its capacity to operate in standalone mode and provide six degrees of freedom (6-DOF), has enhanced both the sense of presence and freedom of movement within the installation, alleviating the constraints imposed by systems reliant on external computers.

In terms of visual and performance optimisation, the adaptation of PBR materials, calibration of optical parameters, and pre-calculation of shadows and reflections have enabled a balance between visual realism and computational efficiency. Similarly, the integration of non-fiducial markers has stabilised the spatial tracking system, mitigating difficulties caused by the visual uniformity of the physical environment.

From a conceptual perspective, the combination of VR and MR has expanded possibilities for artistic exploration, maintaining a connection with real space and enhancing user interaction with the work. The inclusion of physical elements in the tour has been shown to improve spatial perception and reinforce the viewer's sensory engagement with the installation.

Overall, these findings indicate that the integration of XR technologies into art installations not only broadens the expressive potential of the medium but also necessitates a rigorous methodological approach to device selection, graphical resource optimisation, and interaction parameter adaptation.

Future research should investigate how the combination of VR and MR can facilitate greater interactivity and personalisation of immersive experiences, consolidating their role in the evolution of contemporary artistic practice.

Analysis of the survey conducted on the application of virtual reality in art installations reveals a high level of interest and acceptance among respondents, the majority of whom are students of architecture and fine arts, with representation from other disciplines such as design and video games.

Most participants are in the early years of their studies, indicating developing knowledge of XR technologies and their applications in art. A substantial proportion of respondents reported familiarity with virtual, augmented, and mixed reality, albeit at varying levels, with video games, education, and architecture being the primary contexts in which they had engaged with these technologies.

Regarding the use of VR in artistic creation, it was found that, although most respondents were not aware of works developed exclusively in virtual environments, approximately 85% considered VR a valid tool for artistic production. The advantages highlighted include the creative freedom afforded by experimentation in digital environments without physical constraints, the possibility of generating immersive experiences unattainable in the real world, and the expanded accessibility of art through digital platforms. However, technical and conceptual challenges were also identified, such as the optimisation of materials in virtual environments to improve realism and performance, the need for appropriate equipment to enable fully immersive experiences without hardware limitations, and differences in perception between digital artistic creation and its materialisation in physical space.

A key component for the continuity of the research was the analysis of results obtained from surveys conducted during European Researchers' Night 2024 at Francisco de Vitoria University. At this event, an immersive experience was developed, accompanied by a round-table discussion, in which participants underwent a structured three-phase evaluation process. Initially, they completed a diagnostic survey to assess their knowledge of virtual reality and heritage recovery. They then interacted with the work developed in the research through VR glasses, exploring an installation designed specifically for mixed reality. Finally, a post-experience survey measured participants' perception of immersion and the extent of learning acquired, followed by a round-table discussion on the project's potential and its possible applications across various fields.

Initially, an analysis of the audience profile was conducted to determine its composition and demographic characteristics. Although the activity was specifically aimed at certain university students, the open and free-access nature of European Researchers' Night enabled participation by a diverse audience. This approach served a clearly informative purpose, fostering interaction between the academic community and the wider public, with the aim of broadening knowledge and promoting accessibility to innovative scientific and artistic experiences. The perceived relevance of the activity varied according to participants' areas of specialisation: architecture students emphasised its applicability in the projection and design of site-specific spaces, while those from artistic disciplines highlighted its potential to expand creative possibilities and improve access to works that are otherwise difficult to experience. However, opinions were divided on whether a fully virtual art installation can provide the same sensory experience as a physical one.

Consequently, the survey was administered to a sample composed primarily of university students in the early years of creative disciplines, predominantly architecture, fine arts, design, and video games, alongside a minority of professionals and academics. Participants exhibited varying levels of familiarity with XR technologies, with greater exposure to VR in the contexts of video games, education, and architectural visualisation. Their profile indicates an emerging interest in integrating immersive environments into artistic creation, albeit with differing degrees of knowledge and practical experience in applying these technologies.

The results of the initial survey reveal a positive perception of VR for the preservation of historical monuments and the recreation of ephemeral art installations, with a significant proportion of respondents recognising these technologies as valuable tools for both heritage conservation and artistic experimentation. Most participants, particularly students of architecture, fine arts, and design, agreed that VR facilitates the visualisation of structures that have disappeared or are in a state of deterioration, providing an immersive experience that allows for a deeper understanding of the aesthetic and spatial qualities of the works.

It was also observed that perceptions of the usefulness of virtual reality vary. While some participants argued that VR enhances visual perception and allows for greater conceptual flexibility, others highlighted the absence of tactile and olfactory stimuli as a limitation, potentially affecting the authenticity of the artistic experience.

With regard to the perception of colour, transparency, and reflections in virtual environments, the data indicate that a substantial proportion of respondents consider these elements to be well represented. Nevertheless, areas for improvement remain in terms of realism and fidelity to the physical experience. The importance of complementing visual immersion with additional sensory elements, such as background music, was also emphasised, as this was identified as a factor that significantly enhances the immersive experience.

These findings suggest that VR is perceived as an innovative tool with a positive impact on heritage preservation and artistic creation. However, its optimal implementation requires technological advancements that enable the effective integration of a multisensory experience, approximating physical reality as closely as possible.

Figure 4. European Researchers' Night: *Virtual Maze 2.0* Exhibition and Round-Table Discussion

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Source: Adrián Fuentes, 2024

After completing the initial survey and participating in the designed mixed reality experience, visitors completed a second evaluation, the results of which are presented below.

The survey indicates that most participants consider VR to facilitate the development of more ambitious and large-scale artistic projects. However, some respondents observed that fully recreating a space digitally may weaken the viewer's connection with the materiality of the artwork, thereby raising questions about the relationship between virtuality and the traditional aesthetic experience. A noteworthy finding is the widespread lack of familiarity with the concept of ephemeral art installations, emphasising the need to increase understanding and provide targeted training in this field.

Figure 5. European Researchers' Night: Immersive Installation, *Virtual Maze 2.0*

Source(s): Adrián Fuentes and authors elaboration, 2024

3.2. *Conclusions and Comparative Analysis of the Impact of Virtual Reality on the Perception and Use of XR Technologies in Art and Heritage Conservation*

In conclusion, the survey results indicate a favourable trend towards the integration of XR technologies in artistic production, particularly within visual and architectural disciplines, although both technical and conceptual challenges remain. The optimisation of graphics and materials, access to specialised hardware, and the exploration of the impact of virtuality on viewer perception are fundamental for establishing virtual reality as a viable tool in the evolution of artistic installations.

While its application opens new expressive possibilities and extends the frontiers of contemporary art, further research is required to investigate how the combination of physical and digital environments can enhance the aesthetic experience without compromising its original meaning.

Finally, a comparative analysis of the two surveys was conducted to achieve a more comprehensive evaluation of the data collected. This followed a systematic procedure involving the identification of key variables, the organisation of information in a comparative table, and the quantitative analysis of the differences observed between the two measurements.

Figure 6. Comparison of survey results from European Researchers' Night 2024

Categoría	Encuesta Inicial (%)	Encuesta Final (%)	Diferencia (%)
Conocimiento previo sobre realidad virtual	40	75	35
Percepción de utilidad en conservación patrimonial	55	85	30
Aceptación de la realidad virtual como medio artístico	50	80	30
Valoración de la experiencia inmersiva	45	90	45
Percepción de calidad de color y transparencia	60	88	28
Interés en futuras experiencias de realidad virtual	50	82	32

Source: Authors elaboration, 2025

The comparative analysis of the surveys conducted before and after the mixed reality experience enables an evaluation of the evolution in participants' perceptions regarding the usefulness and effectiveness of virtual reality in art and heritage conservation. Concerning prior knowledge of VR, 40% of participants reported familiarity with the technology before the experience. Following the immersive activity, this figure increased to 75%, reflecting a 35% rise and indicating that the activity contributed significantly to broadening public understanding of VR and its applications.

Regarding the perceived usefulness of VR in heritage conservation, 55% of respondents initially believed that it could play a relevant role in preserving historical and cultural heritage. After the experience, this proportion rose to 85%, representing a 30% increase and demonstrating that direct interaction with the technology enhanced participants' understanding of its potential for the preservation and recreation of historical spaces.

With respect to the acceptance of VR as an artistic medium, only 50% of participants initially considered the technology a valid tool for artistic expression. Following the activity, acceptance increased to 80%, a growth of 30%, indicating that the immersive experience positively influenced perceptions of digital art and its potential as an innovative medium. The most substantial increase was observed in the assessment of the immersive experience itself: prior to participation, 45% of respondents had positive expectations regarding VR's capacity to generate immersive experiences; after the experience, this figure rose to 90%, an increase of 45%, suggesting that practical engagement with the technology exceeded expectations and fostered a more favourable appreciation of its impact.

With regard to the perception of colour quality and transparency, the initial positive assessment was 60%, rising to 88% after the experience, a difference of 28%. This suggests that the visual aspects of the simulation provided a convincing representation for most participants, although there remains scope for improvement in the fidelity and realism of the graphical elements. Interest in participating in future VR experiences also increased markedly: prior to the activity, 50% of respondents expressed interest in exploring additional applications of the technology, rising to 82% afterwards, reflecting an increase of 32%. This finding reinforces the notion that direct engagement with immersive environments positively influences participants' perceptions and willingness to utilise VR in different contexts.

Overall, the results demonstrate a significant increase in the positive perception of VR across multiple dimensions, indicating that the immersive experience not only enhanced knowledge of the technology but also influenced evaluations of its application in heritage conservation, artistic production, and the creation of immersive experiences. The most pronounced change was observed in the assessment of the immersive experience itself, which increased by 45%, suggesting that direct interaction with VR exceeded initial expectations. Likewise, interest in future applications grew by 32%, highlighting greater openness to exploring its potential.

Despite these advances, areas for improvement were identified, particularly regarding the quality of visual elements such as colour and transparency, which, while positively evaluated, still require optimisation. In conclusion, the implementation of VR in educational and artistic contexts proves to be an effective tool for dissemination and experimentation with new forms of expression and heritage conservation, suggesting that immersive experiences can foster greater acceptance and understanding of the technology, thereby promoting its integration across diverse fields of application.

3.3. Prospective Approach to Artistic Creation with XR Technologies: Integrating Virtual, Augmented, and Mixed Reality in Contemporary Art Installations

Following the completion of *Virtual Maze* and *Virtual Maze 2.0*, and having confirmed the viability of the initial hypothesis, the study is proposed to continue using a similar approach, with a primary focus on creation rather than mere recreation, while retaining the fundamental principles established in the earlier phases.

The immersive experience is further enhanced in *Virtual Maze 2.0* through the implementation of mixed reality, which superimposes the exhibition model onto the real space, allowing multiple viewers to explore it simultaneously. This approach opens a pathway in which artificial intelligence may play a decisive role in future developments, improving the quality of superimposition and thereby enhancing the immersive experience.

The *Virtual Art Processes* (VAP) project is proposed as a forward-looking initiative, aimed at integrating advanced virtual reality (VR), augmented reality (AR), and mixed reality (MR) tools into the creative processes of artistic works, with particular emphasis on art installations. Traditionally materialised in physical media, works of art have evolved from two-dimensional painting to three-dimensional sculpture, adapting to new forms of expression over time.

The emergence of art installations as a distinct genre reflects a conceptual evolution in which artists seek to engage the viewer within the spatial and temporal dimensions of the work. Recent immersive technologies, including VR, AR, and MR, have facilitated a qualitative leap by transforming the physicality of installations and offering new dimensions to the works. This evolution necessitates an update to the creative processes that underpin them.

The primary objective of the *Virtual Art Processes* (VAP) project is to identify and develop the key elements necessary for creating artistic works using immersive technologies, exploring their potential within the field of art installations. In particular, virtual reality (VR) offers new possibilities for the creation of ephemeral installations, which can persist unchanged in virtual space despite the transitory nature of their physical form. The project thus seeks not only to examine the technical capabilities of these tools, but also to reconceptualise creative processes and their application in contemporary art.

The creative process in art installations incorporating immersive technologies (VR, AR, MR) is distinguished by the inclusion of additional phases, such as immersion and synesthesia, which emerge during the final stages of development and communication. The execution of these works departs from traditional material approaches, prioritising virtual, perceptual, and interactive elements that engage the viewer. This process is characterised by a dynamism that integrates artistic vision, technical expertise, and collaborative effort to create immersive experiences that challenge perception and elicit emotional responses.

The integration of immersive technologies expands creative possibilities by providing novel tools for expression, interaction, storytelling, and collaboration, thereby promoting innovation, experimentation, and inclusion. While VR installations share certain conceptual processes with traditional installations, such as thematic development and audience participation, they differ in terms of spatial design, interactivity, narrative construction, and simulation. Virtual reality fundamentally

transforms artistic creation by enabling greater creative freedom and emphasising interactivity, personalisation, and accessibility.

This approach, which foregrounds sensory immersion and viewer interaction, redefines the conception of the artistic work. It aligns with a historical trajectory of immersive art that can be traced to the Renaissance, when the development of perspective challenged two-dimensionality. The research aims to investigate more deeply the convergence of art installations and virtual reality, exploring the new creative processes that arise at this intersection.

4. Acknowledgements

This text was produced within the framework of the *VIRTUAL MAZE 2.0* project, *Virtual and Extended Reality in the Creative Process of Artistic Installations Inspired by the Myth of the Labyrinth*, funded by the Vice-Rectorate for Research and Postgraduate Studies under the Research Promotion and Development Programme at Francisco de Vitoria University.

The project was carried out in collaboration with María João Durão, director of the Color Laboratory (LabCor) and the Color and Light Research Group of CIAUD at the Faculty of Architecture of the University of Lisbon.

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