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Digital Storytelling and Cultural Learning through Projection Mapping Technique

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Abstract

This study presents the development process of an audio-visual exhibition titled "Portable Western," that utilizes video mapping techniques to showcase the rich culture and folk stories of Xinjiang, China. The production of the exhibition involved a collaborative effort among researchers, creative content and technical experts specializing in illustration, animation, instructional design and projection mapping. The primary objective of the exhibition was to introduce and celebrate Xinjiang's cultural heritage through a dynamic and immersive digital storytelling format. Additionally, the project sought to explore and expand the potential applications of projection mapping in the domain of digital storytelling by highlighting its potential in creating engaging and educational visual narratives. The findings offer valuable insights into the key components and interdisciplinary collaboration required for such projects. It would also demonstrate how audio-visual technologies may be leveraged for digital storytelling in cultural preservation and education.

Introduction

The concept of "immersion" has been introduced across various aspects of daily life and has evolved into a notable trend. Immersion could refer to the degree to which an individual is enveloped by and absorbed into an experience, where the boundaries between the real and virtual worlds become blurred. Slater and Wilbur (1997) describe it as "the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding, and vivid illusion of reality to the senses of a human participant." As technologies like virtual and extended reality have developed, immersion is no longer limited to scientific use. It could now be applied in diverse disciplines such as education, art, culture and the humanities.

Immersive experiences in the cultural domain have taken on many forms including immersive art exhibitions, performances, light shows and other innovative formats. Museums, in particular, are seizing the opportunities presented by immersive technologies to enhance visitor engagement and experience. They are incorporating novel ideas to cater to visitor needs and enrich their overall experience. This shift is crucial as museums strive to remain relevant and appealing in the face of rapid technological advancements. Immersive environments could also heighten the sense of presence by allowing individuals to connect more deeply with cultural artifacts, narratives and artistic expressions. This enhanced engagement is particularly evident in exhibitions like "Van Gogh: The Immersive Experience," which employs VR and projection mapping to enable visitors to step inside the artist's world, transforming passive viewing into an interactive and embodied encounter (Yu, 2022).

In the field of education, digital storytelling has emerged as a powerful collaborative tool with substantial pedagogical value. It enables students to explore and communicate their experiences while fostering a deeper understanding of cultural differences and expanding their knowledge (Alismail, 2015; Jakes, 2006). Digital storytelling is also effectively employed in cultural learning spaces such as museums. For example, the Qing Dynasty Royal Fairy Garden exhibition in Yuanmingyuan, Taiwan has utilized projection mapping techniques to showcase the Emperor Qianlong's Southern Tour and promote heritage conservation awareness. Similarly, the Kirini project in the Cycladic islands of Greece has used projection mapping to highlight beekeeping heritage and raise public interest in preserving cultural assets (Din et al., 2015; Ioakeim et al., 2021).

Within the Malaysian context, there is still limited research exploring the potential and impact of immersive digital storytelling. While immersive technologies are gaining global traction across various sectors, local academic investigations into how these tools can be used to tell stories, preserve culture or enhance audience engagement are still in their early stages. Existing studies primarily explore trends in augmented reality, cultural heritage, and digital museums, providing insights mainly for

policymakers and industry practitioners rather than visitor learning experiences (Junaini et al., 2021). This highlights a need for more focused research on how immersive digital storytelling influences visitor engagement and educational outcomes. Therefore, this paper aims to propose a method to develop an audio-visual production and outlines the key components involved. It also attempts to serve as a preliminary study to explore the potential of projection mapping techniques in supporting cultural learning through digital storytelling.

Digital Storytelling and Cultural Learning

Digital storytelling has witnessed significant growth in popularity and emerged as a global phenomenon (Robin, 2006). Practitioners worldwide are increasingly leveraging digital storytelling to integrate technology into educational settings, with studies showing its positive impact on enhancing student engagement, motivation, language proficiency, and critical thinking skills (Moradi & Chen, 2019). Digital storytelling fundamentally integrates traditional narrative practices with contemporary digital media, employing elements such as text, imagery, recorded narration, music, and video. Through the creative use of digital tools, these components are synthesized to construct narratives that typically center on particular themes or personal perspectives (Robin, 2008).

In recent years, digital storytelling has become one of the key focuses for cultural institutions, reflecting its growing significance in the field of cultural heritage (Birchall & Faherty, 2016). The implementation of digital storytelling as a medium for engaging individual users with cultural heritage has demonstrated its effectiveness in fostering engagement, promoting learning, and encouraging deeper reflection, even among visitors who may not have a specific interest in certain historical periods or themes. This approach has been recognized for its potential to motivate in-depth historical research with key storytelling elements such as humour, connections to contemporary life, an informal tone, and the unconventional use of characters, being particularly influential in achieving educational objectives within non-formal learning environments (Katifori et al., 2020; Roussou & Katifori, 2018).

Coerver (2016) underscores the importance of transitioning from a mere presentation of facts to storytelling, which allows cultural heritage consumers to form emotional connections with the material. This could then lead to fostering curiosity and deeper engagement. Coerver also argues that "what most visitors really need is a story—a memorable, emotionally resonant way to fundamentally connect with foreign objects," which highlights the essential role of storytelling in cultural heritage experiences. The critical role of storytelling in cultural heritage is further elaborated by Pujol et al. (2012), who emphasize its effectiveness in stimulating curiosity, enhancing engagement, and facilitating learning.

Storytelling not only enables individuals to re-experience their heritage (Abrahamson, 1998) but also serves as a powerful tool for transmitting cultural values and reinforcing socially acceptable beliefs and behaviours. Bruner (1990) identifies storytelling as the "first and most basic form of human learning," which aids in the creation of meaning through the "imaginative state" it engenders. According to constructivist theories of learning, stories are more easily remembered than isolated facts due to their structured nature and their ability to connect with prior experiences, thereby enhancing the retention and understanding (Pujol et al., 2012).

Role of Exhibitions in Knowledge Construction for Learning

Exhibitions are seen to be potentially playing a vital role in the construction of knowledge for cultural learning, aligning closely with the principles of constructivist education. It is also used as one of the dominant approaches in museum education. According to the theoretical framework of museum education, learning experiences can be categorized into four types: didactic-interpretive, stimulus-response, discovery-learning, and constructivist approaches (Hein, 2002). Among these, the constructivist approach is particularly significant as it emphasizes active learning where knowledge is not simply transmitted from teacher to student but is actively constructed by the learner through interaction with the environment. Through the careful curation of artifacts, visual displays, multimedia presentations and interactive elements, exhibitions could create a unique space where cultural narratives are not only presented but also actively interpreted by the audience. This process of interpretation is central to knowledge construction as it allows visitors to connect new information with their existing knowledge, which thereby facilitating the construction of new meanings and understandings.

The theory of knowledge construction, as articulated by Scardamalia and Bereiter (1991), asserts that while the world is objective, our understanding of it is subjective. It is often shaped by individual cognitive processes. This theory highlights the importance of developing a learner's overall competence – moving beyond the acquisition of knowledge for specific tasks to fostering a broader and more integrative capacity for understanding. Exhibitions, through their interactive and immersive nature, embody this approach by providing environments that stimulate curiosity, critical thinking and reflection. They allow visitors to construct knowledge in a way that is meaningful to them. In the context of exhibitions, this constructivist model is highly relevant.

Exhibitions are designed to engage visitors in both "hands-on" and "minds-on" activities as encouragements for visitors to interact with the displays, interpret the information and draw their own conclusions. Rather than passively receiving information, visitors are invited to explore, question and synthesize new knowledge. It is a process that mirrors the constructivist idea that understanding the world is shaped by individual experiences and interpretations. The role of the exhibition curator is much

like that of a teacher in a constructivist classroom. The curator shall organize, assist, guide and facilitate this learning process, rather than to directly impart knowledge. By situating individual objects within a coherent storyline, exhibitions could help visitors to understand the significance of these artifacts. There are not exhibited just as isolated items, but as integral parts of a larger cultural context. This contextualization encourages visitors to make connections between different cultural elements and foster a more comprehensive understanding of the subject matter.

Therefore, exhibitions could contribute to knowledge construction for cultural learning by providing immersive, contextualized and interactive environments that encourage visitors to actively engage with the content. Through the integration of narrative, technology and social interaction, exhibitions enable visitors to construct new meanings and connect with cultural heritage on a deeper level. This could assist in developing a more comprehensive and reflective understanding of the world around them. As such, exhibitions play a significant role in the ongoing process of cultural learning, while helping to preserve and transmit cultural knowledge across generations.

Projection Mapping Technique

Exhibitions often incorporate various forms of digital storytelling and interactive technology, which have been shown to enhance learning outcomes by promoting engagement, reflection, and critical thinking. Digital mediums, such as virtual reality and interactive displays, allow visitors to explore cultural content in a more dynamic and personalized manner and support active learning processes. These technologies also enable the incorporation of multiple perspectives and voices, enriching the narrative and providing a more inclusive and multifaceted understanding of cultural heritage.

In contemporary practice, the technologies driving digital storytelling have evolved to include Virtual Reality (VR), Augmented Reality (AR) and Spatial Augmented Reality (SAR) (Quah & Ng, 2022). These technologies significantly enhance audience engagement by utilizing large screens and immersive soundscapes to maintain attention for extended periods (Wang & Anastopoulou, 2020). However, the implementation of VR and AR could be accompanied by challenges such as user discomfort including vertigo and nausea, which may negatively impact user perception and experience. Additionally, the high costs associated with equipment and ticket prices can be prohibitive for both exhibition organizers and attendees. Conversely, Spatial Augmented Reality (SAR) offers distinct advantages by enabling users to interact with real-world environments without the need for head-mounted displays or smartphones which could distract users from their intended experiences. By projecting images and animations onto physical surfaces, SAR fosters greater public interaction with the surrounding space (De Paolis et al., 2022).

Projection mapping is a prominent technique within SAR. It is a technique that transforms objects—frequently with irregular shapes, into dynamic display surfaces for video projection. This process involves the use of specialized software to spatially map the objects, allowing the software to interact with a projector and accurately align any desired image onto the object's surface. The outcome is a visually captivating display that creates the illusion of transforming the physical object.

When integrated with digital storytelling and interactivity elements, the projection mapping technique could positively impacted ways visitors engage with intangible cultural heritage (Nikolakopoulou et al., 2022). For instance, in their study on the Mastic Villages, they observed that this technology facilitates a more dynamic and interactive museum experience, distinguishing it from traditional static displays. Visitors frequently engage with projection mapping in pairs or groups, such as families, friends or organized parties. This interactive technique allows for a collaborative viewing experience where individuals can rotate and interact with the projections together. Such a participatory approach fosters joint interaction among visitors, enhancing the overall experience and making the exhibition more engaging compared to conventional and passive viewing methods.

Design and Development: Case Study of "Portable Western"

The exhibition titled "Portable Western" is held at the Digital Art Gallery in Kuala Lumpur, Malaysia. Designed as a continuous loop, the exhibition has a total duration of approximately 7 minutes and is set within an enclosed space measuring around 250 square feet room.
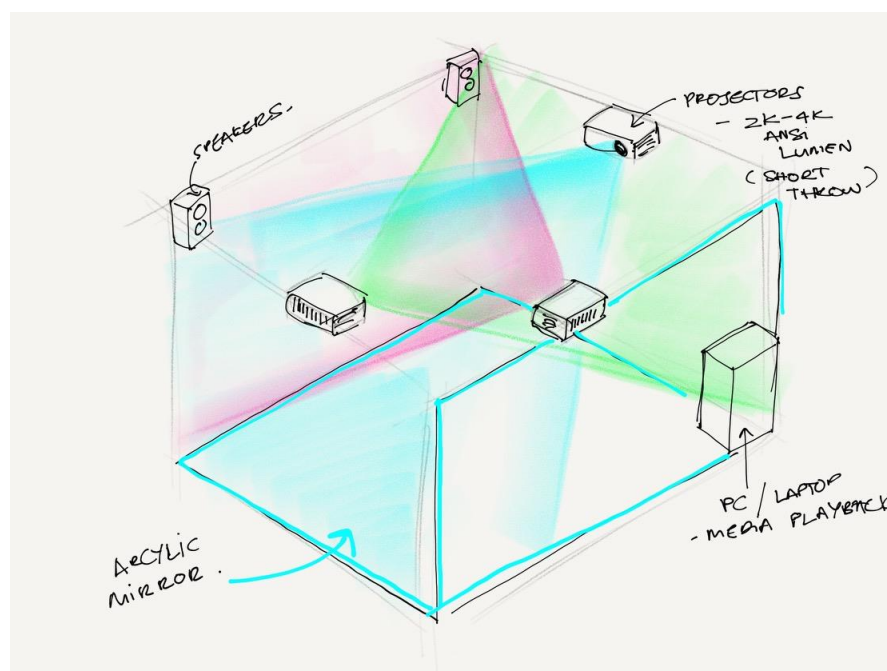

Figure 1. Sketch of Digital Art Gallery Room Layout and Projector Placement

In creating an immersive environment for the audience, the presentation utilizes projection mapping technique that uses three projectors with 3000 ANSI lumens brightness and short throw lenses to display the artworks across three walls and the floor. An acrylic mirror is placed on the floor, sized according to the dimensions of the room to further enhance the visual depth and create a reflective illusion. A uniform background music score is employed throughout the exhibition to enhance the atmosphere and provide a cohesive sensory experience.

Ensuring that the visual content aligns accurately with the physical contours of the room is crucial for creating a seamless and immersive experience in projection mapping projects. To achieve precise alignment, a test card in the shape of a "T" is often employed during the calibration phase. This "T"-shaped test card simulates the layout of the room's walls, allowing for the projection to be mapped accurately onto multiple surfaces. By using this test card, the projection can be adjusted and fine-tuned to account for the specific dimensions and angles of the walls, ensuring that the final visual display fits perfectly within the architectural space. This technique is essential for maintaining the integrity of the visual content and for enhancing the overall effectiveness of the projection mapping installation.
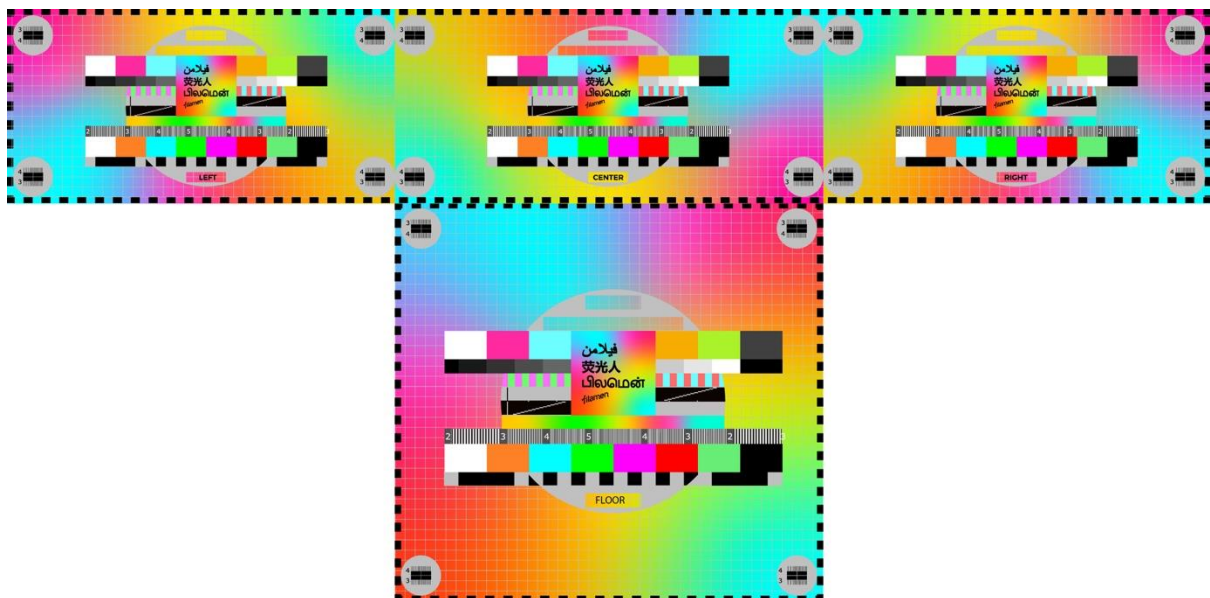

Figure 2. "T" Test-card of Digital Art Gallery

Adobe Premiere Pro and Adobe After Effects were employed to facilitate the video editing and composition process for the projection mapping. These industry-standard tools enabled detailed control over the sequencing, visual effects, and integration of multimedia elements within the work. The final video outputs were then rendered in .mov or .mp4 formats encoded using the DXV codec, which is specifically optimized for real-time playback and compatibility with projection mapping environments. As a specialized codec, DXV is designed to manage high-resolution content and multiple video layers effectively. It achieves this by utilizing GPU-based processing to enhance playback efficiency and

ensure stable performance in real-time projection mapping contexts. Resolume Arena was utilized for the calibration and alignment of the visual content onto the physical surfaces. This software offers advanced capabilities for video mapping, including surface warping, edge blending and spatial calibration to ensure precise synchronization between the digital projections and the architectural features of the exhibition space.

Content and Concept Overview

This exhibition stems from the dynamic intersection of Xinjiang's ethnic cultural elements with the iconic Journey to the West literature. This fusion seeks to reimagine and convey these cultural narratives to a broad audience, both within China and internationally. The exhibition is titled "Portable Western," with "Portable" symbolizing the ease with which these rich cultural elements can be experienced regardless of geographical constraints. The term "Western" refers not only to the geographical direction but also to the legendary Journey to the West. It focuses on drawing connections between the timeless narrative and the diverse cultural expressions of Xinjiang. By curating and showcasing the most representative and artistically significant aspects of Xinjiang including its landscapes, architecture, costumes and humanistic traditions—the exhibition provides a comprehensive and immersive cultural experience.

The thematic concept of exhibition is rooted in the classic Chinese literary work – "Journey to the West". Many of the story's key episodes are situated in the Xinjiang region of China, known for its expansive landscapes, arid climate and rich cultural heritage. The narrative follows the protagonists as they traverse significant locations such as the Flaming Mountain, the Silk Road and Kashgar. It offers a glimpse into the culture, cuisine and human experiences of Xinjiang. This exhibition aims to capture these cultural elements through a modern, digital art medium and provide a contemporary reinterpretation of the traditional narrative.

The aim of "Portable Western" is not only to present a visual feast but also to foster a deeper understanding and appreciation of the cultural diversity and historical richness of western China. Through each carefully crafted illustration, the exhibition intends to capture the essence of Xinjiang's cultural identity and weave together the threads of its past and present. The audience is invited to embark on a cultural journey that mirrors the epic adventures in Journey to the West, even if they are unable to physically visit Xinjiang or fully engage with the literary work.

The exhibition is divided into three thematic episodes, each offering a unique perspective on Xinjiang's cultural heritage:

i. "Fantasy of the West"

This opening episode focuses on Xinjiang's ethnic costumes. It uses the narrative of Tang Monk from Journey to the West as a thematic anchor. The series begins with a depiction of the Tang Monk traversing the desolate desert of the Flaming Mountain. Exhausted and dehydrated, he collapses under the relentless sun. In his weakened state, he experiences a series of vivid hallucinations. These visions blend scenes from Journey to the West with fantastical imagery, creating a surreal narrative that reflects both the physical and spiritual challenges of the journey. The costumes presented in this series are not just traditional attire; they are infused with the symbolic meanings and stories of the people who wear them to provide a window into the rich cultural tapestry of Xinjiang's ethnic groups.

Figure 3. Still illustrations from "Fantasy of the West" mapped to "T" test-card

ii. "The Road to the West"

The second episode shifts focus to the landscapes, architecture and humanistic elements of Xinjiang. It portrays the region's unique geographical and cultural features. This series offers a visual exploration of the majestic mountains, vast deserts, and ancient architectural marvels that define Xinjiang's physical landscape. It also explores the lives and traditions of the people who inhabit this region, while highlighting their resilience, creativity and deep connection to the land. The illustrations in this series serve as a tribute to the enduring spirit of the Silk Road, which historically linked Xinjiang to the broader world. It facilitates cultural exchange and fosters a rich mosaic of human experiences.
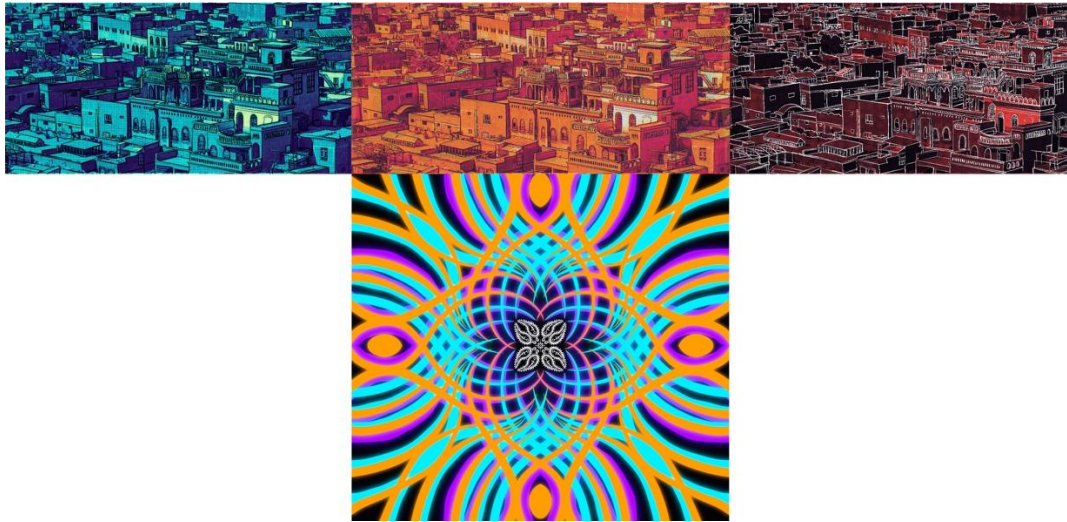
Figure 4. Still Illustrations from "The Road to the West" Mapped to "T" Test-card

iii. "Western Patterns"

The final episode presents an artistic reinterpretation of Xinjiang's characteristic patterns and motifs. These patterns, which have been passed down through generations, are emblematic of Xinjiang's cultural heritage. The episode reimagines these traditional designs by integrating them into contemporary artistic expressions that resonate with modern audiences. By doing so, it could bridge the gap between past and present, tradition and innovation and showcase the timeless beauty of these patterns while also exploring their potential for new creative interpretations. This episode underscores the adaptability and enduring relevance of Xinjiang's cultural symbols in a rapidly changing world.

Figure 5. Still Illustrations from "Western Patterns" Mapped to "T" Test-card

Through these three episodes, "Portable Western" not only brings together the diverse cultural elements of Xinjiang but also invites the audience to experience them in a deeply personal and

meaningful way. The exhibition aims to transcend the boundaries of time and space and allow visitors to connect with the cultural essence of western China, whether they are physically present or engaging with the exhibition from afar.
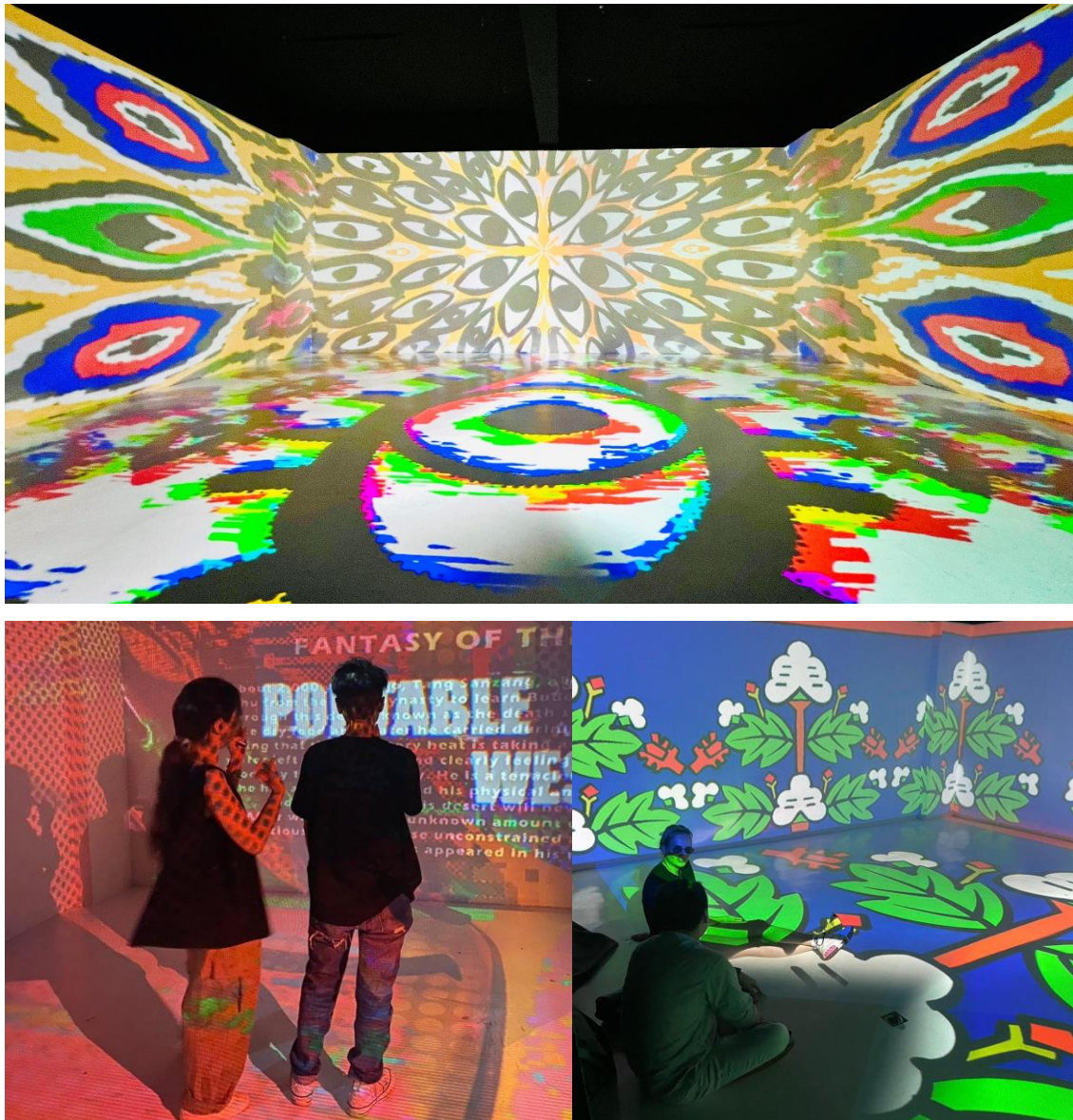

Figure 6. Exhibition Site with Visitors

Components of the Projection Mapping Project for Digital Storytelling

The successful execution of a projection mapping project for digital storytelling depends on the seamless combination of different key components. Table 1 and Table 2 depicts the description of items and their role in creating digital storytelling.

Key Component 1: People

Table 1. People and Role for Digital Storytelling

Item	Description	Role for Digital Storytelling
Graphic Illustrator	Creates static visuals, illustrations and graphic elements that form the foundation of the visual content.	Provides the essential visual elements that communicate the story's themes and concepts, ensuring that the visual narrative is clear and engaging.
Animator	Brings illustrations and visuals to life through motion, adding dynamic elements to the story.	Enhances the storytelling by introducing movement and transitions, making the narrative more captivating and immersive for the audience.
Audio Designer	Develops the soundscape, including background music, sound effects, and voiceovers that accompany the visuals.	Adds an auditory dimension to the experience, reinforce the mood, atmosphere and emotional impact of the story, while also synchronizing sound with visual events for a cohesive experience.
Instructional Designer	Designs the structure and flow of the content to ensure it is educational, engaging and aligned with project goals.	Ensures that the story is easy to follow and meets the learning or thematic objectives, tailoring the narrative to the audience's needs and enhancing their understanding of the content.
Curator	Selects and organizes the content, ensuring it aligns with the exhibition's theme and objectives.	Provides context and coherence to the exhibition, guiding the narrative direction and ensuring that all elements align with the overarching story and message.
Mapping artist	Specializes in aligning the digital content with the physical surfaces using projection mapping technology.	Ensures that the visuals are precisely projected onto the intended surfaces, accounting for the architecture of the space, which is critical for maintaining the immersive and accurate presentation of the digital story.

Key Component 2: Technical Specification

Table 2. Technical Specification and Role for Digital Storytelling

Item	Description	Role for Digital Storytelling
Projector	Suitable resolution device that projects the visual content onto the physical surfaces.	Critical for delivering sharp and clear images, ensuring that the visuals align perfectly with the architecture or objects, creating a visually compelling storytelling experience.
Sound system	Audio setup that includes speakers and sound equipment to deliver music, sound effects and narration.	Enhances the storytelling by adding an auditory layer that complements the visuals, creating an engaging and multi-sensory experience for the audience.
Computer	Central control unit that runs the mapping software, manages the visuals, and controls the projections.	Essential for processing and managing the digital content, the computer ensures that the visuals, sound, and mapping software work together seamlessly throughout the projection mapping project.
Mapping Software	Specialized software used to align and map the digital visuals onto the physical surfaces with precision.	Integral for accurately mapping the visuals onto uneven or complex surfaces, allowing the content to be projected in a way that enhances the narrative and fits the environment perfectly.

Conclusion

This production is an attempt to demonstrate how projection mapping technique could be used as an enabler for digital storytelling. According to Hidi and Renninger's (2006) Four-Phase Model of Interest Development, environmental factors can trigger situational interest by capturing individuals' attention and fostering engagement. In the context of museums, thoughtfully arranged exhibits may serve to stimulate visitors' situational interest. To allow learners access into a deeper learning phase, they should first experience the phase of seeing, hearing and doing at the same time. This is where the learners could construct their own perception of knowledge (Falk, 2016). The combination of audio-visual and video

presentations could also create a good immersion experience by providing the basis for emotional experience and higher-order self-awareness experience.

However, despite these advancements, research has predominantly focused on the technological aspects of content delivery rather than the audience's learning experiences within digital storytelling environments. There is a notable gap in evaluating visitor satisfaction and learning outcomes in immersive cultural settings. Museums, unlike hotels or tourist destinations, often lack comprehensive evaluation processes and objective surveys to assess visitor habits, interests and experiences (Suroto et al., 2020).

Moving forward, our future goal is to expand this study to acquire further insights on how immersive digital narratives may impact learning experiences and to provide documentation of the development pipeline based on both practical and theoretical considerations. Future research could include a comparative study between conventional projection video displays and projection mapping techniques, focusing on audience feedback in terms of immersion, storytelling effectiveness and perceived learning outcomes. This approach aims to provide a more holistic understanding of how immersive technologies influence engagement and educational value in cultural exhibitions.

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