Exploring the Impact of Immersive Projection Art on Visitor Behavior and Engagement

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Abstract: *This study examines the impact of immersive projection art on visitors' emotional, cognitive, and behavioral engagement, using case studies of the China Grand Canal Museum, teamLab Planets in Japan, and ARTE MUSEUM in South Korea. The results indicate that historical and cultural venues enhance cognitive comprehension, art exhibitions emphasize emotional and behavioral interactions, and nature-themed experiences evoke deeper resonance through multisensory stimulation. Immersive projection fosters emotional immersion and cognitive absorption, enhances the depth of interaction, and stimulates exploratory behavior. This study provides valuable insights for future venue designs in terms of technology integration, multisensory engagement, and content innovation, contributing to the creation of more engaging and educational immersive experiences.*

Keywords: Immersive projection, Visitor engagement, Emotional resonance, Cognitive absorption, Multisensory experience.

1. Introduction

With the advancement of digital technology, immersive projection art has emerged as a key approach to enhancing visitor experiences in tourism venues. By integrating projection technology, interactive visuals, and multisensory experiences, visitors can immerse themselves in virtual environments, fostering emotional resonance and cognitive engagement through visual and auditory stimuli. In recent years, museums, science centers, and art galleries have widely adopted immersive projection to enhance interactivity and attractiveness. Studies indicate that immersive experiences improve visitor engagement across emotional, cognitive, and behavioral dimensions, transforming visitors from passive spectators into active participants. However, research on the impact of immersive projection art on visitor engagement remains limited. Therefore, this study explores its application in tourism venues and analyzes how it influences visitors' emotional, cognitive, and behavioral engagement (Jiwane & Khan, 2020).

This study employs qualitative research and case analysis to uncover the mechanisms through which immersive projection enhances visitor engagement and to examine its application across different types of tourism venues. The research scope includes the China Grand Canal Museum, ARTE MUSEUM in South Korea, and teamLab Planets in Japan, investigating the impact of immersive projection on visitor experiences across different cultural contexts. A qualitative research approach is adopted to capture visitors' subjective perceptions and interactive behaviors, while case analysis is used to examine how different venue design strategies influence visitor experiences (Creswell & Poth, 2017). Data collection includes questionnaires, interviews, and case studies, employing a combination of open-ended and Likert-scale questions. Online interviews are conducted to gather visitor feedback, and the analysis is structured around three dimensions—emotional, cognitive, and behavioral engagement (Denzin & Lincoln, 2011).

2. Theoretical Consideration

2.1 Concept and Development of Immersive Projection Art

Immersive projection art relies on digital technology to construct a multi-sensory experience system, enabling users to immerse themselves in virtual or mixed environments through simulated settings and interactive design. This technology is widely applied in fields such as education, entertainment, art, healthcare, and engineering to enhance user engagement and experience (Hutson et al., 2024). In education, immersive projection creates dynamic learning environments that facilitate deep learning and skill development (Al-Juboori, 2024). In the fields of art and entertainment, immersive technology disrupts traditional viewing modes, transforming visitors from passive observers into active participants (Punpeng & Yodnane, 2023), demonstrating its vast application potential.

The origins of immersive projection art can be traced back to panoramic paintings and IMAX cinemas of the late 19th century. In the mid-20th century, multi-screen projection emerged, exemplified by the Czech production Laterna Magika, which marked the birth of immersive environments. In 1992, projection blending technology further enhanced the sense of immersion. In the 21st century, CAVE display environments supported multi-user shared immersive virtual reality, driving the advancement of this technology. Overall, immersive projection art has continuously integrated technology and art, evolving from multi-screen projection to holographic projection and virtual reality, enriching visitor experiences and expanding artistic expression possibilities.

2.2 Theoretical Framework of Visitor Engagement and Key Influencing Factors

Visitor engagement comprises three dimensions: emotional, cognitive, and behavioral, all of which impact exhibition evaluation and experience quality. Emotional engagement involves visitors' emotional responses, such as pleasure, excitement, and satisfaction, which influence their satisfaction and willingness to revisit. Cognitive engagement reflects visitors' ability to acquire knowledge and understand

exhibition content, both of which collectively influence behavioral expressions such as interaction and exploration (Taheri et al., 2014). Behavioral engagement refers to the degree of visitor interaction during the exhibition, including interaction with the content or social engagement with others, demonstrating their level of active participation.

Interactive experiences are key to enhancing engagement. Visitors enhance their sense of control and participation through operation and touch, fostering emotional resonance and cognitive involvement. Engagement can be categorized into passive and active forms. Passive engagement involves observing and receiving information, which is common in traditional exhibitions, whereas active engagement relies on interaction and exploration to enhance the overall experience (Ponsignon et al., 2020).

Influencing factors include sensory stimulation, social interaction, and venue design. Visual, auditory, and tactile stimuli enhance immersion and evoke emotional resonance (Guo et al., 2023). Social interaction fosters a sense of belonging and improves exhibition comprehension (Zollo et al., 2022). Venue design elements such as lighting, sound effects, and interactive installations affect experience quality and dwell time, promoting active participation (Forrest, R. 2013). A well-designed environment can increase visitor satisfaction and deepen interaction levels.

2.3 The Impact of Immersive Experience on Visitor Engagement

Immersion is a crucial factor in enhancing visitor engagement. Research has shown that immersion can enhance visitor satisfaction by fostering emotional resonance (Nguyen et al., 2023). In immersive projection art, interaction with projected content allows visitors to establish emotional connections, thereby increasing their sense of engagement and satisfaction.

Immersive projection art stimulates visitors' cognitive engagement through multi-sensory stimulation, enabling them to gain a deeper understanding of exhibition content. Studies indicate that immersive experiences effectively promote information processing and memory retention (Dancstep et al., 2015). Through the combination of visual and auditory elements, visitors are more likely to retain the knowledge acquired during the experience and share or apply it after leaving the exhibition.

Different types of immersive experiences have varying effects on engagement. Some projection art focuses more on visual effects, while others emphasize interactivity. This variation suggests that different visitors choose experiences based on their personal interests (Omran et al., 2024). This provides valuable insights for future venue design, particularly in achieving a balance between visual effects and interactivity.

3. Research Design and Methodology

3.1 Research Design Framework

This study adopts a qualitative research approach, focusing on the impact of immersive projection art on visitor engagement. Qualitative research is exploratory and enables an in-depth

examination of the subtle dynamics and multidimensional relationships behind complex phenomena, making it particularly suitable for understanding visitors' subjective experiences, emotional changes, and behavioral expressions during immersive experiences (Creswell & Poth, 2018).

The research design consists of three parts: The first part involves the design and implementation of questionnaire interviews, aiming to gain an in-depth understanding of visitors' subjective experiences while participating in immersive projection experiences. The second part is the selection and analysis of case venues, where representative tourism venues are chosen as research subjects to ensure the applicability of the study's findings. The third part focuses on data analysis methods, employing qualitative coding, categorization, and case comparison analysis to systematically organize and interpret the data. This study aims to construct a theoretical framework of visitor engagement and reveal the impact of immersive projection art on different types of engagement.

3.2 Data Collection Methods

3.2.1 Design and Implementation of Interviews

To gain a deeper understanding of visitors' immersive experiences, this study adopts an online questionnaire interview approach. This method integrates the core principles of personal interviews into questionnaire design by combining open-ended and closed-ended questions, ensuring both systematic exploration of key issues and allowing respondents to freely express their thoughts and feelings in open-ended questions (Kallio et al., 2016).

The questionnaire design covers three core dimensions: emotional response, cognitive engagement, and behavioral interaction. Emotional response questions explore visitors' emotional changes and subjective perceptions of the projection content during the experience. Cognitive engagement questions focus on visitors' understanding, memory, and knowledge acquisition of the exhibition content. Behavioral interaction questions examine whether visitors engage with the projection content or interact with other visitors during the exhibition. The questionnaire is distributed via the Wenjuanxing online platform to enhance the efficiency and convenience of data collection.

3.2.2 Selection and Analysis Criteria of Case Venues

This study selects three representative tourism venues as case study subjects. These venues demonstrate a certain level of advancement and innovation in the application of immersive projection art and cover different types of tourism experiences to ensure data diversity and result generalizability. The selection criteria include the following aspects:

1) The venue must have a well-established immersive projection experience facility.

2) The venue must have high visitor traffic and recognition, ensuring its representativeness.

3) The venue's application of projection art must be

innovative in design and capable of eliciting strong visitor engagement.

The selection of these venues is also based on the diversity of visitor engagement. The three venues attract visitors of different age groups, cultural backgrounds, and interest preferences, which helps analyze the application effects and acceptance of different immersive projection designs among diverse visitors. This diversity enhances the generalizability of the research findings and provides a rich data foundation for further exploration of the application of immersive projection technology in different types of venues.

3.3 Data Analysis Methods

This study employs qualitative analysis by systematically analyzing interview data through an open coding process. First, the researchers conduct initial coding, breaking down interview content into specific concepts and phenomena. Then, axial coding is used to identify relationships between concepts. Finally, selective coding is applied to form core themes. The analysis focuses on visitors' emotional, cognitive, and behavioral engagement, categorizing them into corresponding themes.

Table 1: Data Analysis Methods and Steps.

Analysis Method		
Qualitative Analysis: Coding and Categorization	This study adopts a qualitative analysis method. Through the process of initial coding, axial coding, and selective coding, it systematically extracts core themes and patterns related to emotional, cognitive, and behavioral engagement. Each interview transcript is analyzed as an independent unit and categorized into corresponding themes to construct a theoretical framework of visitor engagement.	Charmaz (2014)
Steps	Initial Coding: Identify specific concepts and phenomena.	
	Axial Coding: Identify relationships and patterns between different concepts.	
	Selective Coding: Categorize and form core themes.	

3.4 Coding and Analysis of Interview Questionnaire Results

The following is the coding analysis of the 15 interview questionnaire responses. The coding process includes initial coding (extracting key concepts), axial coding (categorizing concepts), and selective coding (refining core themes). During this process, the data is divided into four core themes: emotional engagement, cognitive engagement, behavioral engagement, and sense of immersion, with further refinement of subcategories under each theme.

Table 2: Survey Data Coding Analysis.

Coding Analysis Table			
ID	Initial Coding (Extracted Key Concepts)	Axial Coding (Categorized Themes)	Selective Coding (Core Themes)
1	Awe, resonance, historical atmosphere, lack of interaction	Emotional resonance, insufficient interactivity	Emotional engagement
2	Interest, innovation, technological interaction, creativity	Interest stimulation, interactive exploration	Emotional engagement
3	Visual shock, artistic expression, boundless space	Immersive experience, artistic exploration	Emotional engagement & behavioral engagement
4	Technological effects, dynamic projection, multi-dimensional interaction	Knowledge acquisition, interactive display	Cognitive engagement
5	Historical scene, emotional resonance, cultural depth	Emotional resonance, cultural heritage	Emotional engagement & cognitive engagement
6	Light and shadow effects, artistic aesthetics, interactive experience	Emotional resonance, artistic impact	Emotional engagement
7	Dynamic effects, technological interaction, sensory stimulation	Emotional resonance, interaction and immersion	Emotional engagement & behavioral engagement
8	Interactive installations, immersive experience, artistic space	Emotional engagement, multi-sensory immersion	Emotional engagement & behavioral engagement
9	Digital projection, emotional stimulation, multi-sensory combination	Multi-sensory experience, technical innovation	Emotional engagement
10	Digital display, technological exploration, VR experience	Immersive interaction, technological innovation	Cognitive engagement
11	Abstract visuals, artistic background, creative experience	Abstract expression, artistic creativity	Cognitive engagement
12	Interactive projection, creative exploration, visual effects	Interactive expression, visual immersion	Cognitive engagement
13	Historical scene, artistic expression, virtual experience	Emotional resonance, cultural depth	Emotional engagement & cognitive engagement
14	Dynamic projection, artistic background, spatial exploration	Immersive design, artistic immersion	Emotional engagement & cognitive engagement
15	Virtual vision, technological exploration, new media	Immersive interaction, knowledge acquisition	Cognitive engagement

4. Case Analysis of Immersive Projection Art

4.1 Immersive Projection Experience at the China Grand Canal Museum

4.1.1 Museum Background and Projection Art Design

The China Grand Canal Museum, located in Yangzhou, is a modern comprehensive museum dedicated to the preservation, exhibition, and dissemination of Grand Canal culture. The

River Romance exhibition hall serves as the museum's immersive projection experience zone, utilizing 360° panoramic laser projection technology combined with an open-space design to showcase the natural landscapes and cultural essence of the Grand Canal.

The exhibition is divided into four chapters: "Water," "Transport," "Poetry," and "Painting," each representing cultural imagery, historical heritage, and poetic expressions of the Grand Canal. The entire hall adopts a 450-square-meter

circular spatial layout, allowing visitors to view the exhibition from any angle, experiencing the depth of space and historical atmosphere. Artistic installations suspended from the ceiling create a harmonious visual effect with the projections and the space, making visitors feel as if they are immersed in the flowing culture of the Grand Canal.

4.1.2 Visitors' Emotional and Cognitive Feedback

The immersive design of the *River Romance* exhibition hall has evoked strong emotional resonance and cognitive engagement among visitors. Interview data indicates that visitors generally experience a profound historical impact and resonance, especially when surrounded by the panoramic visual effects, as if witnessing the passage of time along the Grand Canal. Many visitors mentioned the emotional impact of the experience, such as a sense of awe towards the history of the canal (Interview IDs 1, 6, 3).
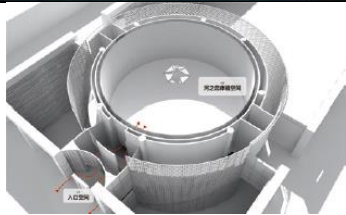
Moreover, the multimedia presentation transforms complex historical knowledge into an intuitive experience, helping visitors gain a deeper understanding of the cultural

background of the Grand Canal. Interview results show that visitors identified as 5, 9, and 12 acquired and retained a substantial amount of cultural knowledge during the exhibition, demonstrating a high level of cognitive engagement.

In terms of behavioral engagement, visitors were able to move freely within the exhibition space and interact with the projection content, further enhancing their sense of participation. For example, interview data from IDs 7 and 13 show that visitors experienced a strong sense of autonomy while exploring the space, increasing their behavioral engagement and overall sense of immersion.

Additionally, the multi-sensory design reinforced visitors' immersive experience, enhancing participation through the combination of visual and auditory stimuli. Interview responses from IDs 8 and 10 also reflect that the rich sensory effects of multimedia presentations deeply immersed visitors, particularly through the integration of visual effects and sound, leading to a more profound emotional experience.

Table 3: Case Analysis of the China Grand Canal Museum, Yangzhou.

Museum Background Introduction	China Grand Canal Museum, Yangzhou, China Project: *"River Romance"* Exhibition Hall	On-site Photo	
Exhibition Content and Technology Application	The exhibition is divided into four chapters: *Water*, *Transport*, *Poetry*, and *Painting*, representing the cultural imagery of the Grand Canal. Technology: 360° panoramic laser projection	Spatial Structure	
Visitor Flow and Spatial Layout	The exhibition hall covers 450 square meters and features a seamless circular layout, allowing visitors to enter from any direction. Artistic installations suspended from the ceiling enhance the three-dimensional sense of space and the cultural atmosphere.	Projection Effects	

Dimension	Details	Visitor Feedback and Interview Data
Emotional Engagement	The immersive experience, combined with visual and auditory effects, enhances visitors' historical resonance and cultural appreciation.	Interview IDs 1, 3, 6 indicate that the immersive projection evoked strong emotional responses, including admiration for historical and cultural details.
Cognitive Engagement	The exhibition content integrates multimedia displays, allowing visitors to intuitively understand and absorb historical and cultural information, fostering cultural learning.	Interview IDs 5, 9, 12 show that the exhibition effectively conveyed historical knowledge, enhancing visitors' understanding of canal culture, achieving cognitive engagement.
Behavioral Engagement	The circular design allows visitors to move freely, increasing interaction with the projected content and engagement in the experience.	Interview IDs 7, 13 highlight that visitors could explore at their own pace, enhancing their participation and immersion.
Multi-Sensory Stimulation and Interaction	The exhibition integrates auditory, visual, and spatial design elements to create a deep sense of immersion.	Interview responses from IDs 8 and 10 suggest that visitors found the combination of multi-sensory effects particularly engaging, especially with synchronized sound and visual effects.
Highlights and Areas for Improvement	Highlights: The projection successfully creates a strong cultural atmosphere. Areas for Improvement: Introduce more interactive features and increase maintenance efforts.	Areas for Improvement: Some visitors (Interview ID 2, 15) felt that the content lacked periodic updates.

4.2 Interactive Projection at ARTE MUSEUM, South Korea

4.2.1 Highly Interactive Immersive Experience Design

ARTE MUSEUM in Busan, South Korea, is themed "*Nature Beyond Time and Space*", offering visitors a highly interactive immersive experience. The exhibition features multiple nature-themed scenes, including beaches, waterfalls, starry

skies, and gardens. Each exhibition area utilizes 360-degree panoramic projection, dynamic sound effects, and scent design to create an immersive natural experience for visitors.

Visitors can move freely within these scenes, and different perspectives and interactive methods provide diverse visual and auditory effects. ARTE MUSEUM's design strongly emphasizes visitor engagement, ensuring that attendees are not merely observers but active participants in the interactive experience. Interview data shows that most visitors responded positively to this free-exploration experience, particularly enjoying the unique interactivity and personalized immersive experience offered by moving through different exhibition zones.

4.2.2 Multi-Sensory Experience and Emotional Resonance

ARTE MUSEUM successfully evokes visitors' emotional resonance through multi-sensory design. The exhibition not only enhances immersion through visual and auditory elements but also incorporates olfactory experiences, allowing visitors to fully engage with the natural atmosphere. Each themed exhibition area features specific scent designs—for instance, floral fragrances in the garden section and the fresh scent of water vapor in the waterfall zone—making visitors feel as if they are truly surrounded by nature.

Interview results indicate that visitors generally expressed high satisfaction with this multi-sensory experience. They believed that this design enhanced the sense of immersion and helped them establish a deeper emotional connection with the exhibition themes. The combination of sensory stimuli had a positive impact on both emotional and cognitive engagement, making visitors feel not only captivated but also as if they were genuinely interacting and communicating with nature.

Table 4: Case Analysis of ARTE MUSEUM, Busan, South Korea.

	Busan, South Korea – ARTE MUSEUM			
Museum Background Introduction	Project: *Eternal Nature*		On-site Photo	
Exhibition Content and Technology Application	Exhibition Content: Immersive experience with multi-themed natural scenes, including gardens, beaches, waterfalls, and starry skies.		Spatial Structure	
	Technology: High-resolution projection, professional sound effects, and scent integration to create a five-sense experience.			
Visitor Flow and Spatial Layout	Visitor Experience: No fixed route; visitors can move freely. Each themed exhibition area combines visual, auditory, and olfactory elements to create unique natural experiences, suitable for all age groups.		Projection Effects	
Dimension	**Details**		**Visitor Feedback and Interview Data**	
Emotional Engagement	The exhibition evokes joy, mystery, and escapism, themed around "Nature Beyond Time and Space", providing a highly immersive experience through the combination of visual, auditory, and olfactory elements.		Interview IDs 1, 6, 10 indicate that visitors were drawn into a rich sensory experience, feeling deeply immersed in the atmosphere, particularly in terms of spiritual and emotional resonance.	
Cognitive Engagement	The exhibition is centered on nature, offering a tranquil visual and auditory atmosphere. Through the artistic presentation of scenes, it encourages visitors to contemplate and immerse themselves in the experience.		Interview IDs 5, 9, 12 suggest that visitors found the exhibition effectively conveyed the beauty and significance of nature, leading to deeper reflection and cognitive engagement.	
Behavioral Engagement	Visitors can explore and interact freely across ten themed areas, stimulating curiosity and enhancing engagement.		Interview IDs 3, 7 indicate that visitors actively interacted with the exhibition areas, exploring different themed zones and engaging deeply in the experience.	
Multi-Sensory Stimulation and Interaction	The integration of visual, auditory, and olfactory elements creates a highly immersive environment, incorporating sensory design to deepen emotional and cognitive engagement.		Interview IDs 8, 13 highlight that the combination of sound, visual effects, and scent significantly enhanced immersion, particularly in terms of emotional resonance.	
Highlights and Areas for Improvement	Highlights: The multi-sensory design creates a highly immersive experience.		Interview ID 13 indicated that visitors were highly engaged in the exhibit's interactive displays. Interview ID 6 noted that excessive olfactory stimulation could be uncomfortable.	
	Areas for Improvement: Some visitors found certain aspects of the sensory experience overwhelming or unsuitable.			

4.3 Projection-Based Narrative Experience at teamLab Digital Museum, Japan

4.3.1 Integration of Immersive Narrative and Cultural Communication

teamLab Planets in Tokyo, Japan, exemplifies a highly immersive form of digital storytelling through its signature

project, *Floating in the Falling Universe of Flowers*. The exhibition area utilizes highly interactive projection art installations and lighting effects to simulate the natural cycle of flowers blooming, withering, and regenerating, symbolizing the perpetual cycle of life. This narrative approach not only delivers a powerful visual impact but also conveys profound reflections on the continuity of nature, embodying Japanese cultural perspectives on the relationship between nature and humanity.

teamLab's design philosophy breaks the boundaries of traditional exhibitions by employing real-time dynamic projections that integrate visitors' actions and experiences into the narrative. This allows each participant to perceive and interpret the artwork from a unique perspective.

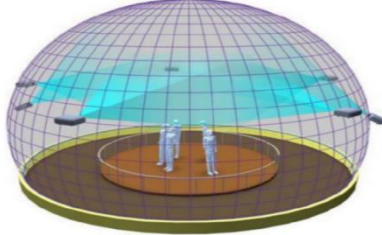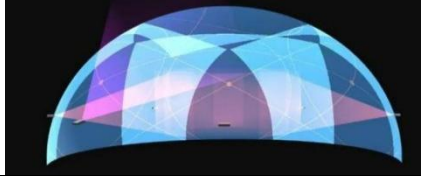4.3.2 Visitor Interaction and Engagement Experience

In the immersive experience of teamLab Planets, visitor interactions become a crucial part of the exhibition. The map-free design encourages visitors to explore freely, while the combination of glass flooring and lighting enhances the sense of spatial extension, making visitors feel as if they are walking through an infinite space.

Interview data indicates that visitors generally responded positively to this participatory design. Through touch and movement, they could interact with the projections and experience different scenes and visual effects (Interview IDs 1, 6). Some visitors specifically noted that this interactive experience not only added an element of fun to the exhibition but also stimulated their curiosity and desire for exploration (Interview IDs 9, 12).

However, some interview data also revealed that certain visitors felt discomfort due to the intense immersive effects (Interview ID 13), suggesting that audience diversity should be considered when enhancing immersion. Overall, the design of teamLab Planets successfully enhances both emotional and behavioral engagement, allowing visitors to form deep connections with the artwork through interaction.

Table 5: Case Analysis of teamLab Planets, Tokyo, Japan.

Museum Background Introduction	Tokyo, Japan – teamLab Planets	On-site Photo	
	Project: *Floating in the Falling Universe of Flowers*		
Exhibition Content and Technology Application	Flowers of all four seasons bloom and wither over time, symbolizing the infinite expansion of life within the space.	Spatial Structure	
	Technology: Highly interactive projection art installations combined with dynamic lighting effects.		
Visitor Flow and Spatial Layout	No fixed map design, encouraging exploration. The integration of glass and lighting enhances the sense of space and immersion.	Projection Effects	

Dimension	Details	Visitor Feedback and Interview Data
Emotional Engagement	Visitors feel awe and a sense of being lost in the dynamic art scenes, experiencing joy, mystery, and deep immersion.	Interview data from IDs 1 and 6 mentioned the sense of awe brought by the immersive experience. IDs 2 and 7 reflected feelings of mystery and joy, enhancing emotional resonance.
Cognitive Engagement	The exhibition stimulates visitors' thoughts and imagination through dynamic art, with various lighting and interactive installations mimicking natural and life processes.	IDs 9 and 12 indicated that visitors engaged in imagination and contemplation during the experience, particularly strengthening their understanding of nature and life.
Behavioral Engagement	Visitors actively interact with the exhibits, exploring different effects; they tend to stay for long periods and frequently revisit the same artworks.	IDs 5 and 10 showed that visitors repeatedly interacted with the exhibits, extending their stay and demonstrating high behavioral engagement.
Multi-Sensory Stimulation and Interaction	The combination of visuals, sound, and dynamic lighting creates a highly immersive experience.	IDs 8 and 13 reported a strong sense of immersion due to multi-sensory stimulation, with the mirrored floor design enhancing the visual effect of an infinite space.
Highlights and Areas for Improvement	Highlights: Interactive design and mirrored surfaces enhance immersion and personalization.	IDs 1 and 13 highlighted positive feedback on the interactive design and unique visual effects. However, ID 6 noted that some visitors felt discomfort due to the intense immersion.
	Areas for Improvement: Some visitors may feel discomfort due to the intense immersive experience.	

4.4 Summary and Comparison of Case Studies

4.4.1 Differences in Visitor Engagement Across Various

Types of Venues

The analysis of the China Grand Canal Museum, teamLab

Planets in Japan, and ARTE MUSEUM in South Korea reveals significant differences in visitor engagement across different types of venues utilizing immersive projection. The China Grand Canal Museum focuses on historical and cultural dissemination, enhancing cognitive engagement through panoramic projection effects, allowing visitors to not only learn about the Grand Canal's history and culture but also experience its depth and solemnity.

teamLab Planets, on the other hand, employs a borderless design to create an environment of free exploration, emphasizing interactivity and visual impact, which significantly enhances visitors' behavioral engagement and makes them an integral part of the experience. In contrast, ARTE MUSEUM stimulates multiple senses, particularly incorporating scent elements, to create an immersive natural experience that strongly resonates with visitors on an emotional level.

These differences indicate that historical museums prioritize cognitive engagement, art exhibitions emphasize emotional and behavioral engagement, while nature-themed venues tend to innovate in emotional and multi-sensory interaction.

4.4.2 The Impact of Immersive Projection Design on Emotion and Cognition

Immersive projection design has a profound impact on both emotional and cognitive aspects of visitor engagement. At the China Grand Canal Museum, panoramic projection vividly presents historical scenes, allowing visitors to not only appreciate cultural heritage but also gain a deeper understanding of the Grand Canal's history. Interview data shows that many visitors developed a more comprehensive knowledge of the Grand Canal's cultural background after their experience.

At teamLab Planets, real-time dynamic projection and interactive design merge nature and art, prompting visitors to develop emotional resonance through interaction, thereby enhancing their level of engagement. Meanwhile, ARTE MUSEUM's multi-sensory design—particularly the integration of visual and olfactory elements—provides visitors with an immersive natural experience that strengthens emotional engagement, making them feel a heightened sense of comfort and pleasure.

Thus, immersive projection not only enhances emotional resonance but also significantly deepens cognitive understanding.

4.4.3 Insights for Future Design Optimization

These case studies provide valuable insights for optimizing future immersive projection designs. First, future designs should be tailored to the theme and target audience of the venue. For instance, historical and cultural museums can further refine cognitive-oriented displays by incorporating more interactive technologies to enhance knowledge dissemination.

Second, for art exhibitions that emphasize interactivity, designers can further utilize dynamic projection and real-time

feedback mechanisms to enhance visitors' behavioral engagement and emotional connection. The multi-sensory design of ARTE MUSEUM suggests that future immersive exhibitions could explore the incorporation of additional sensory elements, such as touch and scent, to create a richer experiential dimension.

Furthermore, future designs should take into account the diverse needs of visitors, ensuring an optimal level of immersion without overwhelming sensory stimulation that might cause discomfort for certain audiences. These optimization recommendations provide direction for the application of immersive projection in different types of venues, ultimately enhancing overall visitor experience and satisfaction.

5. Conclusion

This study conducted a case analysis of the immersive projection experiences at the China Grand Canal Museum, teamLab Planets in Japan, and ARTE MUSEUM in South Korea to explore the impact of immersive projection art on visitors' emotional, cognitive, and behavioral engagement. The research findings indicate that immersive projection plays a unique role in different types of venues:

- **Historical and cultural venues** enhance visitors' cognitive engagement by recreating historical scenes, allowing them to understand and retain the exhibition content more deeply.

- **Art exhibitions** use dynamic interactions and open-space designs to enhance behavioral and emotional engagement, encouraging visitors to explore freely and interact with the artworks.

- **Nature-themed venues** utilize multi-sensory immersive designs to evoke emotional resonance, creating a sense of presence through the combined experience of visual, auditory, and olfactory stimuli.

In terms of emotional and cognitive impact, the application of immersive projection design in different venues has shown significant effects. The panoramic projection at the China Grand Canal Museum enhances visitors' historical resonance and cognitive engagement. teamLab Planets stimulates visitors' curiosity and emotional resonance through real-time dynamic interactions. ARTE MUSEUM, by integrating scent, visual, and auditory elements, creates a multi-layered emotional experience, allowing visitors to feel a deep sense of comfort and fulfillment in natural scenes. These case studies highlight the advantages of immersive projection in enhancing visitor experiences and demonstrate its potential in strengthening emotional resonance and deepening cognitive understanding.

Based on these findings, future immersive projection design can further explore multi-sensory integration, improved interactivity, and periodic content updates to enhance immersion and engagement. Designers can innovate in both technology and content to better meet the needs of different audiences based on the specific requirements of different types of venues. With continuous optimization and innovation,

immersive projection technology has broad application prospects in culture, education, and entertainment. It contributes to the comprehensive enhancement of visitor experiences while providing practical references and theoretical foundations for future venue design.

Acknowledgements

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