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Visitors' Visual Perception of Lighting in the Immersive Space of Sonobudoyo Museum, Yogyakarta

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ABSTRACT

The development of immersive technology in museums has transformed the way visitors experience exhibition spaces through visually dominant environments shaped by lighting and digital projection media. Immersive screen–based spaces utilize controlled lighting conditions, visual contrast, and large-scale displays to create atmosphere and guide visitors' attention toward exhibition narratives. However, interior design studies that specifically examine visitors' visual perception of lighting in immersive museum spaces remain limited, particularly within the context of cultural museums in Indonesia. This article aims to review visitors' visual perception of lighting in the immersive space of Sonobudoyo Museum Yogyakarta through an interior design literature study approach. The research method employs a systematic literature review of books and academic journals discussing visual perception theory, Gestalt principles, interior lighting design, and immersive museum spaces. The findings indicate that lighting plays a central role in shaping visual clarity, spatial depth, and visitors' visual comfort. Lighting intensity, distribution, and contrast between the surrounding space and projection surfaces significantly influence the legibility of visual content and visitors' ability to perceive the space as a coherent whole. Well-controlled lighting also supports visual focus and reduces perceptual distractions in projection-based exhibition spaces. This study concludes that lighting should not be considered merely as a technical support for immersive technology, but as a fundamental interior design element that determines the quality of visual perception and spatial experience. The findings are expected to provide a conceptual basis for designing immersive museum spaces that are more responsive to visitors' visual experience.

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1. INTRODUCTION

The development of digital technology has driven the transformation of museums from conventional exhibition spaces into experience-oriented environments that emphasize visitors' visual engagement. Museums no longer present artifacts solely in a static manner, but increasingly employ projection media, immersive screens, and controlled lighting to create atmosphere and strengthen exhibition narratives (Boletsis & Prillard, 2025). Within this context, lighting becomes an essential interior design element, as it helps direct attention, shape spatial perception, and determine visitors' visual comfort. Research indicates that the quality of contemporary museum experiences is strongly influenced by how light and visual elements are organized within space (Luo et al., 2025).

Sonobudoyo Museum, Yogyakarta is one of Indonesia's cultural museums that has implemented immersive technology-based exhibition approaches. One of its signature spaces is an immersive room known as "Lorong Waktu," which features a curved immersive screen with an approximately 180-degree field of view, combined with large-scale visual projections and controlled lighting conditions. The curved screen is designed to create an enveloping visual environment, allowing visitors to feel immersed in the historical narrative being presented. In this space, lighting does not merely function as illumination, but is specifically arranged to support projection visibility, maintain visual contrast, and reduce distractions from surrounding interior elements.

Previous literature shows that lighting has a significant influence on visual perception and immersive spatial experience. Hu et al. (2024) found that light intensity and visual contrast affect viewers' attentional focus and the legibility of visual content in museum exhibition spaces. Salvadori et al. (2023) emphasized that variations in lighting conditions lead to differences in depth perception and perceived visual scale, particularly in spaces featuring curved display surfaces. Other studies also indicate that uncontrolled lighting in projection-based environments can reduce visual comfort and weaken visitors' sense of immersion, even when the visual technology employed has advanced (Wen & Ma, 2024).

Earlier research further confirms that lighting in exhibition spaces is not only a technical element of illumination, but also contributes to shaping visual comfort and overall visitor experience (Hamdani et al., 2025). Well-designed lighting can create spatial atmosphere and support visual interpretation of exhibition content. Moreover, visual perception is understood as an active process of organizing and interpreting visual elements as a coherent whole, making it relevant for examining visitors' visual experience in large-scale cultural settings (Rahmi et al., 2025).

In the national context, the implementation of immersive spaces in Indonesian museums has begun to be examined through studies that emphasize the role of visual technology in enhancing visitor experience. Sekar et al. (2023) for example, explored the development of a 360-degree immersive virtual museum in West Nusa Tenggara and demonstrated that enveloping visual displays can increase visitor engagement and understanding of historical and cultural narratives. Although the study focused on educational media innovation, its findings highlight that immersive experience quality largely depends on the visual conditions of the space, including lighting arrangements that support visual legibility and strengthen visitors' sense of presence in immersive environments.

Similarly, Isnanda and Ardianto (2023) in their study on the application of Extended Reality (XR) technology in the interior design of the Jember Fashion Carnaval (JFC) Museum, showed that immersive experiences are formed through the integration of audio-visual media, projection mapping, virtual reality, and augmented reality. The study emphasizes that successful immersive user experience is not determined solely by technological

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sophistication, but also by the spatial and interior design strategies that support visual clarity and visitor engagement. Although lighting was not explicitly examined as a research variable, the use of projection mapping and large-scale visual media implicitly requires controlled lighting conditions to ensure clear perception without visual disturbance. This argument is further supported by Zahra et al. (2024) in their study on the immersive experience concept applied to the design of the Merapi Volcano Museum in Yogyakarta, which identified lighting as a factor influencing visitors' visual experience quality. Their findings indicate that excessive natural lighting in digital display–based exhibition spaces can disrupt visitors' focus and reduce visual legibility, thereby weakening the effectiveness of immersive experiences.

Collectively, these studies suggest that lighting is a crucial element in shaping visual perception and the quality of immersive museum experiences. However, most existing research still positions lighting primarily as a technical support for digital displays or as a general atmosphere-forming component. Studies that specifically address the role of lighting in shaping visitors' visual perception from an interior design perspective remain relatively limited. In immersive environments with wide-angle curved screens such as those applied in Sonobudoyo Museum Yogyakarta, lighting plays a strategic role in determining visual clarity, directing gaze, and ensuring visitors' visual comfort, while simultaneously supporting projection visibility and maintaining focused visual experience.

Based on these considerations, this article aims to examine the role of lighting in shaping visitors' visual perception in the immersive space of Sonobudoyo Museum Yogyakarta through an interior design literature study approach. This study focuses on the relationship between lighting arrangements, the visual characteristics of immersive space, and the way visitors perceive visual displays as an integrated whole. The findings are expected to provide a conceptual contribution to the development of lighting design for immersive museum spaces and to serve as a reference for interior designers in creating technology-based exhibition environments that respond to visitors' visual perception and spatial experience (Grütter, 2020).

2. RESEARCH METHOD

This study aims to understand the role of lighting in shaping visitors' visual perception in immersive museum spaces. Therefore, a qualitative approach was employed, with data analysis conducted through a systematic literature study. This approach was selected because it enables the researcher to examine and synthesize various theories and findings from previous studies related to visual perception, Gestalt principles, interior lighting, and immersive museum spaces. Studies that employ a Systematic Literature Review (SLR) provide structured and transparent protocols for identifying, screening, and synthesizing research articles (Zufahmi et al., 2025), therefore, this approach is considered relevant for the present study in order to establish a comprehensive conceptual foundation.

The research data consist of secondary data obtained from journal articles and scholarly sources accessed through various academic databases and scientific publication platforms, such as Google Scholar, Science Direct, MDPI, and other relevant academic journal websites. In addition, contextual data were obtained through documentation and observation of the immersive space at Sonobudoyo Museum, Yogyakarta, which was used as an illustrative case to relate the literature findings to the characteristics of immersive spaces in Indonesian cultural museums. This approach facilitates the identification of lighting aspects that conceptually influence visual focus, visual legibility, and the unity of visitors' immersive spatial experience.

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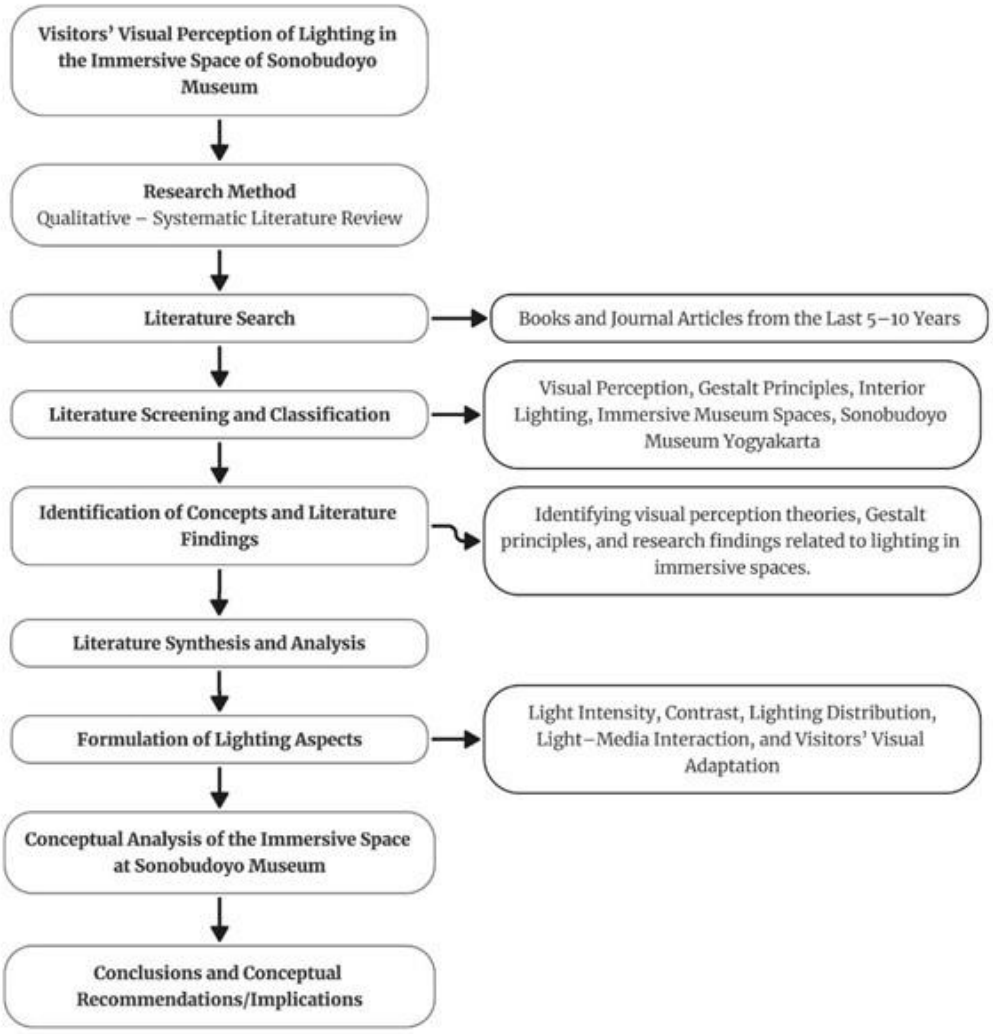

Figure 1 Research Method
Source: Author's analysis, 2025

Based on the research process diagram, the study begins with a literature search of books and journal articles published within the last 5–10 years that are relevant to visual perception, Gestalt principles, interior lighting, and immersive museum spaces. The selected literature is determined based on topical relevance and publication recency, then screened and classified according to thematic categories. Subsequently, key concepts and findings from previous studies are identified and synthesized through descriptive–theoretical analysis. The results of this synthesis are used to formulate lighting aspects that influence visitors' visual perception, which are then analyzed conceptually within the context of the immersive space at Sonobudoyo Museum, Yogyakarta, as the basis for drawing conclusions and developing conceptual recommendations.

3. RESULTS AND DISCUSSION

3.1 Principles of Visual Perception in Immersive Spaces

Visual perception in a spatial context is understood as a cognitive process through which individuals receive, organize, and interpret visual stimuli from the environment to form spatial understanding and spatial experience. Recent studies in design and visual environmental research explain that visual perception is influenced not only by the physical characteristics of stimuli, but also by the relationships among visual elements, the spatial

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context, and the lighting conditions that frame the observer's experience (Salvadori et al., 2023). In immersive museum spaces, visual perception becomes a crucial aspect, as visitors' experiences largely depend on how large-scale visual displays, lighting, and spatial elements are perceived as an integrated whole.

Visitors' visual perception in immersive museum environments is formed through the organization of visual stimuli into a meaningful unity. Gestalt principles explain that humans tend to perceive the visual environment as a coherent whole rather than as a collection of separate elements, making them relevant for understanding visual experience in large-scale immersive spaces (Guberman, 2017; Wertheimer, 1938). In the context of immersive museum spaces, Gestalt principles are used to explain how the relationships between projection surfaces, spatial elements, and lighting shape visitors' visual experiences in a directed and coherent manner.

The figure–ground principle helps visitors distinguish the projection surface as the primary visual focus (figure) from interior elements as the background (ground). This separation becomes more prominent when luminance contrast and spatial lighting conditions are controlled to maintain the legibility of projected visuals (Shi et al., 2025). The continuity principle supports a continuous visual perception within immersive-scale curved display media. Consistency in spatial lighting conditions is also necessary to preserve display legibility and sustain visitors' immersive experience (Urakami et al., 2021). The unity principle is achieved when lighting, projection media, and interior elements are harmoniously integrated, allowing the space to be perceived as a unified visual whole (Grütter., 2020). Meanwhile, the focus principle relates to the ability of lighting to direct visitors' attention toward the projection surface and to maintain visual comfort throughout the immersive experience, which is influenced by lighting intensity and light characteristics (Alketbi & Mushtaha, 2025)

Overall, Gestalt principles indicate that lighting plays an important role in supporting the visual organization of immersive spaces, enabling visitors to perceive visual displays in a directed, coherent, and meaningful way.

3.2 Lighting Aspects in Immersive Spaces

Lighting in immersive museum spaces is an interior design element that plays an important role in shaping visitors' visual perception. Beyond functioning as a source of illumination, lighting regulates visual focus, visual legibility, and overall comfort throughout the immersive experience. Therefore, this literature review formulates the key lighting aspects that influence visitors' visual perception in immersive museum environments, as summarized in the following table.

Table 1 Lighting Aspects in Immersive Spaces

Lighting Aspect	Findings from Literature	Impact on Visual Perception	Reference	Source
Light Intensity	- The level of brightness and darkness of artificial lighting used in immersive spaces is generally kept dim and controlled. - Excessive lighting reduces projection visibility.	Visual focus is disrupted.	(Ma et al., 2022)	Journal; *Building and Environment*
Contrast	High contrast improves legibility.	Visual content appears clearer.	(Takeuchi et al., 2025)	Journal; *Frontiers in Virtual Reality*

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Lighting Aspect	Findings from Literature	Impact on Visual Perception	Reference	Source
Lighting Distribution	Directional lighting is more effective.	Viewing direction is controlled.	(Scorpio et al., 2023)	Journal; *Sustainability*
Relationship between Lighting and Projection Media	Uncontrolled lighting causes glare.	Viewing direction is controlled.	(Visbecq et al., 2025)	Journal; *Frontiers in Virtual Reality*
Visitors' Visual Adaptation	Adaptation to changes in luminance within immersive spaces.	Prevents visual fatigue and helps maintain focus throughout the immersive experience.	(Dresp-Langley & Reeves, 2024)	Journal; *Brain Sciences*

Source: Author's analysis, 2025

3.3 The Immersive Space of Sonobudoyo Museum



Figure 2 Curved Immersive Screen Space at Sonobudoyo Museum
Source: Author's documentation, 2025

The immersive space at Sonobudoyo Museum represents a transformation in exhibition design approaches that are oriented toward visitors' visual experiences. This space is designed as a medium for delivering cultural narratives by emphasizing spatial atmosphere and visual engagement, aligning with the concept of immersive space as a curatorial strategy based on sensory perception (Deng et al., 2023). Located in Unit I of the second exhibition building, the space features a contemporary character with an enclosed visual environment, dark-colored walls, and tightly controlled lighting to support a focused visual experience.

The main element of this immersive space is the Curved Immersive Screen themed "Lorong Waktu," featuring a panoramic projection surface with an approximately 180-degree field of view. Spatially, the room takes the form of a semi-cylindrical enclosure, with curved walls functioning as a projection medium for moving visual content. This configuration creates an enveloping visual environment, in which the boundary between physical space and visual representation becomes blurred (Lee., 2025). As a result, visitors no longer perceive the screen as a separate object, but rather as part of a space experienced in a holistic manner.

In terms of visual perception, lighting plays a key role in shaping the quality of the immersive spatial experience. The lighting is designed to be dim and controlled in order to reduce visual distractions, strengthen contrast between the projection surface and interior elements, and maintain visitors' visual focus on the presented narrative. These lighting

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conditions support the figure–ground principle, where the projection surface functions as the primary visual focus, while other spatial elements serve as supporting background.

The immersive space at Sonobudoyo Museum allows visitors to stand and freely choose their viewing position without a designated viewing distance. Variations in visitors' distance and body orientation toward the curved screen result in diverse visual experiences, which are strongly influenced by visual legibility, viewing angle, and ocular adaptation to the lighting conditions of the space. Therefore, this environment is relevant to be examined from a visual perception perspective, particularly in understanding how lighting contributes to visual clarity, visual focus, and visitors' spatial experience within immersive museum settings.

3.4 Previous Studies

Table 2 Previous Studies

No	Title	Authors	Method	Key Findings	Source
1	*The Impact of Immersive Technology in Museums on Visitors' Behavioral Intention*	(Liu & Sutunyarak, 2024)	VR experiment and subjective assessment	Variations in CCT influence visual perception, visitor preferences, and visual comfort levels during virtual exhibition experiences.	Journal; *Sustainability*
2	*Perception of Light in Museum Environments: Comparison between Real-Life and Virtual Visual Experiences*	(Çevik et al., 2022)	Comparative survey and perception evaluation	Lighting perception is influenced by spatial characteristics and visual media; differences between environments result in differences in visual perception.	Journal; *Sustainability*
3	*Light Environment Evaluation of the Architecturalized Immersive New Media Public Art Installation from the Audiences' Visual Safety Perspective*	(Yan et al., 2023)	Visual evaluation and luminance testing	Curved screens require controlled luminance and contrast to ensure that visual content remains legible and comfortable for visitors.	Journal; *Buildings*
4	*A Study on Color Visual Perception of Museum Exhibition Space Based on Eye Movement Experiments*	(Hu et al., 2024)	Eye-tracking and questionnaire	Visitors' visual focus and visual experience are influenced by dominant visual elements and the legibility of displayed content.	Journal; *Frontiers in Psychology*
5	*The impact of artificial lighting on improving the visual experience*	(Alketbi & Mushtaha, 2025)	Quantitative descriptive analytical approach	Well-designed artificial lighting enhances visitors' visual comfort and psychological	Journal; *Heritage and Sustainable*

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No	Title	Authors	Method	Key Findings	Source
	of museum visitors: A case study of Sharjah Museum of Islamic Civilization			experience by improving artifact visibility, reducing eye fatigue, and strengthening the spatial atmosphere. In addition, lighting adjustments in specific gallery areas have been shown to improve visual quality and visitor experience through simulation and illuminance optimization.	*Development* (HSD)
6	Inovasi Media Pembelajaran Sejarah dan Budaya Berbasis Museum Virtual Ruang Imersif 360 di NTB	(Sekar et al., 2023)	Qualitative approach and media development	Immersive, enveloping visual spaces increase visitors' interest and engagement with cultural narratives.	Article; Prodiksema: Prosiding Seminar Nasional Pendidikan Sejarah Dan Ilmu Sosial
7	Implementasi Konsep Immersive Experience pada Desain Museum Gunungapi Merapi Yogyakarta	(Zahra et al., 2024)	Qualitative approach	Excessive natural lighting disrupts visitors' focus and reduces the legibility of digital displays.	Journal; Jurnal Arsitektur ARCADE

3.5 Theoretical Analysis Results

Based on the synthesized literature, lighting in immersive museum spaces conceptually plays an important role in shaping visitors' visual perception. The characteristics of immersive spaces being enclosed, using wide-angle curved screens, and positioning visual projection as the dominant element indicate that lighting should not be understood merely as an illumination component, but rather as a regulator of the visual experience. The literature suggests that dim and controlled lighting can be interpreted as a design strategy to reduce visual distractions and direct visitors' attention toward the projection surface. In immersive museum environments such as those implemented at Sonobudoyo Museum Yogyakarta, this lighting approach has the potential to support visual focus and enhance the legibility of exhibition narratives.

When viewed through Gestalt principles, appropriately controlled lighting theoretically strengthens the figure–ground relationship, in which the projection surface is perceived as the primary visual focus while interior elements function as a supporting background. As described in the literature, luminance contrast between the projection surface and the surrounding space helps maintain visual legibility as well as the continuity of visual flow on curved screens. Moreover, the integration of lighting with spatial configuration and projection

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media conceptually supports the unity principle, allowing immersive spaces to be perceived as a cohesive, atmospheric visual whole. The focus principle can also be achieved through luminance differences between the projection area and the visitor area, enabling visitors to maintain visual attention despite variations in viewing position and distance. These lighting aspects are summarized in a conceptual framework diagram to illustrate the relationships among intensity, contrast, lighting distribution, and the interaction between light and projection media in shaping visitors' visual perception based on Gestalt principles.

Thus, the theoretical analysis indicates that, according to the reviewed literature, lighting is an interior design element that plays a strategic role in shaping visual perception and enhancing the quality of immersive spatial experiences in museum environments.



Figure 3 Conceptual framework of the theoretical analysis of immersive museum lighting in shaping visitors' visual perception based on Gestalt principles
Source: Author's analysis, 2025

4. CONCLUSION

Based on the systematic literature review and theoretical analysis conducted in this study, it can be concluded that lighting is a strategic interior design element in shaping visitors' visual perception in immersive museum spaces, particularly in projection-based exhibition environments such as the "Lorong Waktu" space at Sonobudoyo Museum Yogyakarta. Lighting functions not only as illumination, but also as a regulator of visual experience quality, influencing display legibility, visual comfort, and visitors' ability to perceive the space and exhibition narrative as an integrated whole.

The findings indicate that the quality of visual perception in immersive environments is influenced by dim and controlled light intensity, luminance contrast between the projection surface and surrounding spatial elements, lighting distribution that supports viewing direction, and the control of lighting in relation to projection media to prevent glare and unwanted reflections. In addition, visitors' visual adaptation to changes in luminance is an important factor in maintaining comfort and reducing visual fatigue throughout the immersive experience. Conceptually, these lighting aspects reinforce Gestalt principles figure–ground, continuity, unity, and focus thereby enabling immersive spaces to be perceived as more coherent, directed, and meaningful.

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5. RECOMMENDATIONS

Based on the findings of this study, several conceptual recommendations can be proposed for the design of immersive museum spaces, namely:

1. Implementing dim and controlled lighting **to** maintain the legibility of projected content and to direct visitors' visual focus.
2. Maintaining clear luminance contrast between the projection surface and the surrounding areas to ensure that the display remains the primary point of attention.
3. Applying directional lighting in circulation areas or specific points to support visitor orientation without disrupting the projected visuals.
4. Minimizing light sources that may cause glare and unwanted reflections on the projection surface.
5. Considering visitors' visual adaptation comfort by designing lighting transitions that are not extreme, in order to reduce visual fatigue during the immersive experience.

As a further development, this study may be extended through empirical approaches (e.g., behavioral observation, questionnaires, or illuminance measurements) to directly examine the relationship between lighting aspects, visitors' visual perception, and visual comfort in immersive museum environments.

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