

Designing Inclusive Museum Spaces: A Study on Spatial Strategies for Sensory Engagement and Accessibility for People with Visual, Auditory, and Physical Disability

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Abstract

Museums have evolved from conventional spaces of display into dynamic environments that promote learning, cultural exchange, and public engagement. Despite this transformation, many museum environments continue to present physical, sensory, and cognitive barriers that limit participation for individuals with visual, auditory, and physical disabilities. Inclusive museum design therefore requires a shift from accessibility as an added feature to accessibility as a fundamental design principle embedded within spatial experience. This research investigates architectural and spatial strategies that support sensory engagement and universal accessibility in museum environments. The study examines how circulation planning, sensory zoning, tactile wayfinding systems, lighting design, acoustic control, and multisensory exhibit formats can contribute to more inclusive visitor experiences. A mixed-method approach was adopted, combining literature review, case study analysis, observational findings, and evaluation of established inclusive environments such as Enabling Village, Singapore, and Nanjing Museum, China. Particular attention was given to the role of touch, sound, movement, and spatial sequencing in enhancing independent navigation and meaningful interaction for users with diverse abilities. The findings indicate that inclusive museum spaces are characterized by barrier-free circulation, multimodal interpretation systems, accessible information delivery, and sensory-rich environments that accommodate different modes of perception. The study further highlights the importance of integrating universal design principles during the earliest stages of planning rather than treating accessibility as a later intervention. By promoting equal participation, comfort, autonomy, and emotional well-being, inclusive design enriches the museum experience for all visitors. The research concludes with a set of practical recommendations intended to guide architects, designers, Curators, and institutions in creating museum environments that celebrate diversity, foster belonging, and support meaningful cultural engagement.

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INTRODUCTION

Museums are widely regarded as spaces of learning, culture, and collective memory; however, for many visitors with disabilities, they still operate as environments of partial or complete exclusion. Architectural decisions about circulation, materials, lighting, and sound are often privileged for sighted, able-bodied users, leaving others dependent on assistance or unable to participate fully.

This research, titled “Designing Inclusive Museum Spaces: A Study on Spatial Strategies for

Sensory Engagement and Accessibility for People with Visual, Auditory, and Physical Disabilities,” investigates how museums can be reimagined as inclusive, multisensory environments rather than primarily visual institutions. It focuses on spatial strategies—such as tactile wayfinding, acoustic comfort, controlled lighting, and accessible exhibit interfaces—that enable people with diverse sensory and mobility needs to navigate, interpret, and enjoy museum spaces with dignity and independence.

Architect Juhani Pallasmaa, in *The Eyes of the Skin*, reminds us that architecture is not only to be seen but also felt, heard, and experienced through all the senses. This idea forms the foundation of inclusive design: spaces should communicate beyond vision. Museums, in particular, hold great potential to engage touch, sound, texture, temperature, and even smell to create meaningful experiences for all visitors, especially those with sensory impairments.

An inclusive museum is one that speaks through sound, touch, light, and movement, not just sight. Every spatial element, from layout and material choice to lighting and acoustics, contributes to how people perceive and interact with the environment; when design considers varied sensory experiences, it transforms a museum from a place of observation into one of participation and discovery.

This study aims to explore how architectural spatial strategies, such as circulation planning, sensory zoning, and material detailing, can create inclusive environments that celebrate diversity in perception. The goal is to move from static displays to dynamic, human-centered museum spaces that engage every sense and visitors equally. It will explore how architecture can create equal experiences for all visitors. By focusing on spatial design, sensory experience, and universal accessibility, it seeks to redefine museums as inclusive, engaging, and truly human-centered environments.

Objective

- To explore how spatial design can create inclusive museum environments that engage all senses and make cultural experiences enjoyable for everyone, while focusing on disabilities such as vision, hearing, and physical disabilities.
- To understand how sensory elements, such as light, sound, textures, and spatial sequencing, can enhance visitors' emotional and physical connection with exhibits.
- To identify design strategies that move beyond sight-dominated experiences and promote multisensory engagement for a richer, more inclusive interaction with spaces.
- To study how accessibility can be integrated seamlessly into design rather than added as an afterthought, ensuring dignity and independence for all users.
- To examine real-world examples of inclusive spaces to derive practical design insights for future museums.
- To develop a framework that combines sensory awareness.
- Accessibility, and human-centered design principles for creating truly inclusive museum experiences.

Scope

- This study examines how spatial design (layout, entrances, circulation, and exhibit sequencing) and sensory strategies (tactile elements, soundscape, lighting control, and multisensory interactives) can improve museum experiences for people with visual, auditory, and Persons with Disabilities (PWD).
- This draws on the idea that architecture should engage all senses, not just vision, to create meaningful experiences (a central theme from Pallasmaa's *The Eyes of the Skin*). This helps ground the research in a sensory-first design philosophy.
- This research uses existing case studies, scholarly papers, and documented best practices (including work on tactile exhibits, multisensory programming, participatory design with people with learning disabilities, and global inclusive built environment case studies) to identify practical spatial strategies.

- This study will produce a set of practical and adaptable design recommendations for architects, museum educators, curators, and students written in clear, actionable language so that they can be applied in different cultural or budget contexts. The overall research workflow adopted for this study is illustrated in Figure 1.

Limitations

- *Based on secondary research:* This study relies mostly on books, research papers, and case studies, with limited direct user testing or on-site surveys.
- *Covers only three disability groups:* This research focuses on visual, auditory, and PWD. Therefore, it does not delve deeply into cognitive or neurodiverse needs.
- *Varies by museum context:* Since museums differ in size, culture, climate, and budget, some design suggestions may need local adjustments.
- *Broad but technical:* This study offers practical and easy-to-use strategies rather than detailed technical guidelines tailored to each type of disability or sensory intervention.

LITERATURE REVIEW

Understanding Inclusivity as a Multisensory Experience

Across all reviewed literature and case studies, a central idea emerges: an inclusive museum is one that speaks to multiple senses, not only vision. For visitors with visual, auditory, and physical disabilities, sensory diversity is not an “extra feature”—it is the core of accessibility.

Research, such as the *multisensory approach to museum accessibility* [1], emphasizes that relying solely on sight excludes large groups of visitors. Engaging touch, sound, texture, temperature, and movement creates richer, more democratic learning experiences (Figures 2 and 3).

Spatial Strategies that Support Independent Navigation

Clear Circulation Paths

Both field studies and site audits show that most difficulties arise when movement is confusing. Wide corridors, consistent flooring, and step-free routes—as seen in the Nanjing Museum and Enabling Village—allow visitors with physical disabilities or low vision to move independently.

Predictable Spatial Sequencing

Museums with linear, thematic progression reduce cognitive load and anxiety. Studies on visually impaired visitors note that predictable transitions between galleries help build mental maps and allow safer navigation.

Tactile Wayfinding

Many visually impaired participants in field surveys preferred subtle tactile cues—textured floor strips, handrails, or relief markers—that guide movement without depending on staff support. Figure 4 illustrates tactile floor guidance systems used for navigation.

Enhancing Sensory Engagement Across Disability Groups

Tactile Access and Hands-On Exhibits [1–3]

The reviewed literature consistently indicates that tactile engagement is one of the most effective methods.

Examples include:

- Replica artefacts for touching
- Raised diagrams
- 3D printed models
- Material samples such as stone, wood, metal

Among the eight interview participants, six stated that tactile exhibits made them feel "more connected" and "less excluded." (Figure 5).

Controlled Lighting for Low-Vision Comfort [1–5]

Research shows that uneven lighting, glare, and high-contrast transitions create barriers for low-vision visitors.

Case studies highlight

- Diffused ambient lighting
- Adjustable spotlighting
- Glare-free materials
- Illuminated signage

These techniques support both sensory comfort and emotional ease. Examples: At the Nanjing Museum, diffused ambient lighting is combined with anti-glare display cases and illuminated circulation routes. These lighting strategies reduce visual fatigue for visitors with low vision while maintaining appropriate conservation standards for artefacts. Such interventions demonstrate how lighting functions not merely as illumination but as an architectural tool supporting inclusive perception.

This approach reflects Pallasmaa's argument that light shapes emotional and spatial experience rather than simply revealing objects.

Soundscapes and Assistive Listening [1, 2, 4, 6, 7]

Visitors with hearing impairments benefit from

- Hearing-loop systems
- Captioned videos
- Directional speakers to avoid auditory clutter
- Quiet zones to reduce sensory overload

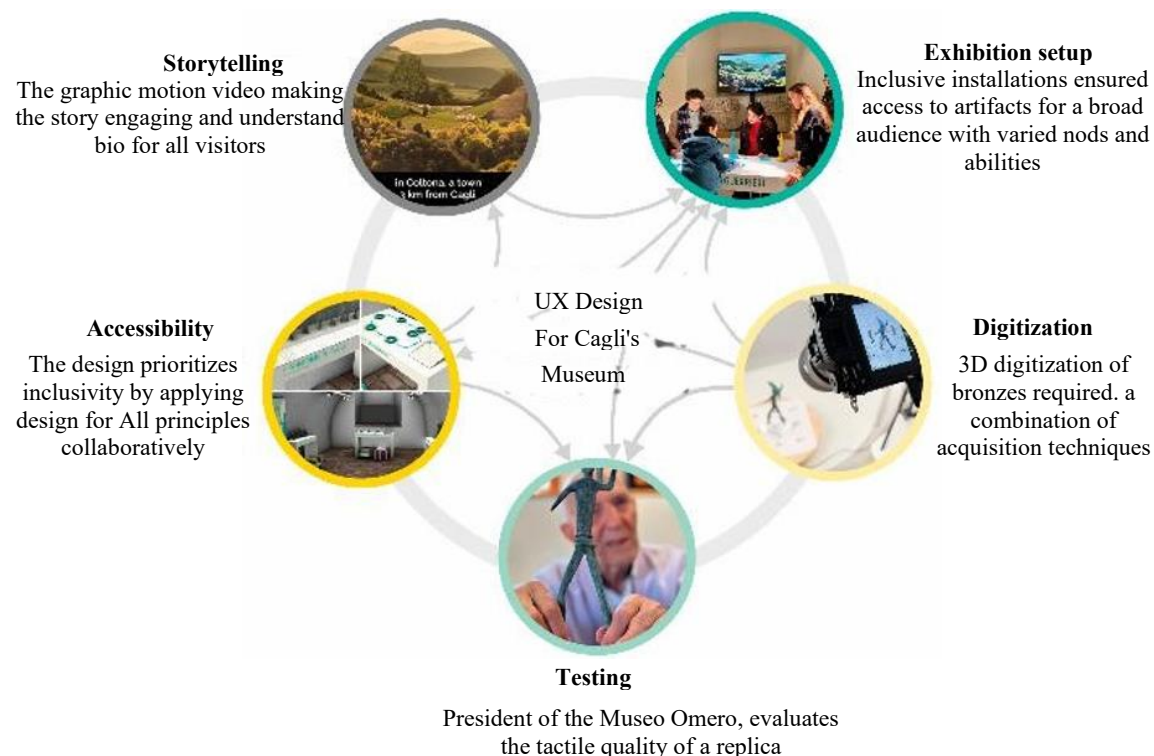


Figure 1. Chart of the user experience (UX) design adopted in the present study.



Figure 2. LinkedIn.



Figure 3. Tactile images at the Louvre.



Figure 4. Tactile floor pathway.

In the Nanjing Museum, hearing-loop systems, directional speakers, and acoustically separated exhibition spaces reduce overlapping sound sources. Quiet zones positioned away from multimedia galleries provide low-stimulation environments where visitors experiencing sensory fatigue can comfortably rest before continuing the museum route.



Figure 5. Replica artefact exhibit being used in a museum.



Figure 6. Hearing-loop signage.

This demonstrates Pallasmaa's phenomenological idea that hearing contributes equally to the perception of architectural space.

Studies also show that environmental soundscapes (e.g., historical ambience) enhance immersion for visitors who rely more on auditory cues.

Figure 6 shows a hearing-loop system commonly used in inclusive museums.

Inclusivity Through Interpretation Tools

Multimodal Information [6, 7]

Across all research papers, one shared conclusion is that information must be delivered in multiple formats.

- Large-print labels
- Braille text
- Tactile graphics
- Audio description
- Sign language videos
- AR-based narration



Figure 7. Inclusive signage examples.

Universal Signage Principles

Signs with high-contrast, simple icons, and consistent placement reduce stress for all visitors, not only for those with impairments. Examples of inclusive wayfinding signage are illustrated in Figure 7.

Findings from Field Observations and User Feedback

In total, eight participants took part in semi-structured interviews, including three architects, two museum professionals, one accessibility consultant, and two visitors with disabilities, aged 24–56 years. This mix of professional and lived-experience perspectives ensured that sensory and accessibility issues were examined from both design and user standpoints.

Direct observations conducted during the case study analysis, together with responses collected from interviews and questionnaires, revealed four recurring themes:

Visitors with visual impairments feel most included when tactile access and audio descriptions are offered together.

- Visitors with auditory impairments prioritize captioning, clear sightlines, and reduced echo.
- Visitors with physical disabilities express strong preference for step-free circuits, adequate resting points, and wheelchair-friendly exhibit heights.

Many users shared that emotional safety— feeling comfortable, not rushed, and not “dependent”— is as important as physical accessibility.

Gaps and Challenges Identified

Despite significant progress, challenges remain

- Tactile elements are not available consistently across galleries.
- Soundscapes can overlap, causing discomfort for hearing aid users.
- Some museums lack quiet rooms or low-stimulation zones.
- Wheelchair drop-off points are often far from entrances.
- Staff training varies, affecting the reliability of accessibility support.

These gaps highlight the need for continuous improvement rather than one-time compliance.

Synthesis: What Makes a Museum Truly Inclusive?

Based on the literature, field data, and case studies, an inclusive museum is one that:

- Supports movement through clear, step-free, well-lit circulation
- Engages multiple senses through tactile, visual, and auditory elements
- Communicates equally through multimodal interpretation
- Respects bodily differences in height, reach, hearing, sight, mobility
- Reduces emotional fatigue by providing comfort, predictability, and autonomy.

Emergent Themes

Thematic analysis of interview and workshop transcripts revealed four recurring themes:

- Emotional safety and independence as core measures of accessibility.
- Preference for tactile and audio interpretation among visually impaired visitors.
- Need for quiet, low-stimulation zones to balance immersive multimedia displays.
- Importance of staff training and consistent wayfinding for confidence in navigation.

Questionnaire Findings

Visitor questionnaires and feedback forms indicated that respondents with visual impairments consistently described tactile maps and floor guidance systems as ‘very helpful’ in supporting independent navigation. Respondents with hearing impairments frequently emphasized the importance of captioned media and hearing-loop systems, noting that these tools allowed them to participate in exhibitions without relying on staff assistance (Figure 8). Together, these responses reinforce international accessibility studies that stress the need for multimodal information delivery, where tactile, visual, and auditory channels work in combination rather than in isolation.

Implications for Future Museum Design

Future museums must shift from “accessibility as add-on” to accessibility as design philosophy, integrating sensory engagement from the start of the design process.



Figure 8. Designs for different types of information.

- Escalators and stairs run parallel in the museum (left), and their representations are on several floors (right).
- Dome Theater (left) and its representations on several floors (right).
- One exhibit area (left) and its representation on one floor (right).
- Eight symbols that represent museum facilities.

Designers should prioritize:

- Co-design workshops with disabled users
- Sensory zoning in early planning
- Flexible, multisensory exhibit formats
- Continuous post-occupancy evaluation

Inclusivity becomes successful not when everyone enters space, but when everyone feels welcome, comfortable, and able to belong.

METHODOLOGY

This study uses a mixed methods, case study approach to understand how spatial strategies support sensory engagement and accessibility for visitors with visual, auditory, and physical disabilities. It combines literature-based theory (phenomenology of multisensory architecture) with empirical analysis of exemplar sites (e.g., Enabling Village/Singapore and multisensory exhibitions), designer interviews, visitor questionnaires, direct observation, and participatory workshops.

Research Design

- *Approach*: Mixed methods (qualitative dominant) integrate qualitative case studies and interviews with quantitative visitor survey data to triangulate findings and produce robust, actionable strategies.
- *Rationale*: Qualitative techniques capture sensory, emotional, and embodied responses that numerical metrics often miss; targeted quantitative questions provide comparability and highlight trends. The design is informed by phenomenological ideas in Pallasmaa's *The Eyes of the Skin* and recent multisensory museum research [8, 6].

Case Study Selection and Site Analysis

Primary Case(s)

1. *Enabling Village, Singapore*: a built, award-winning community and training hub that intentionally integrates universal design and multisensory programming. Site documents and project analyses will be used as primary case references [9]. Key accessibility and community integration features are shown in Figure 9.
2. *Nanjing Museum, China*- Multisensory Engagement Strategies: The museum integrates tactile replicas, raised-relief maps, controlled lighting, and immersive soundscapes to ensure that visitors with visual and auditory impairments can engage beyond purely visual displays. These multi-layered sensory cues enrich interpretation and support equal access to information.

Accessible Spatial Planning

Wide, step-free circulation paths, spacious galleries, consistent flooring, and barrier-free entries create an intuitive, obstacle-free route for wheelchair users and visitors with mobility impairments. Clear sequencing and wayfinding reduce cognitive load and enhance independence.

Tactile Pathways

Tactile pathways within the Nanjing Museum employ high-contrast paving modules to differentiate circulation routes from surrounding floor finishes. Consistent with guidelines on tactile paving surfaces, such pathways typically use durable materials such as vibro-compressed concrete, porcelain stoneware, rubber, or PVC, with raised ribs and domes that are perceptible underfoot and with a cane. In the museum's Boai Gallery for visually impaired visitors, these textured strips align key decision points (entrances, intersections, exhibit thresholds), creating a continuous tactile narrative across the building.

Inclusive Interpretation Tools

Braille labels, large-print text, subtitles for audiovisual media, audio guides, and hearing-loop systems allow diverse disability groups to receive the same content through different sensory channels, ensuring information equity.



Figure 9. Participants of the Australia- based Enabled Futures immersion programme during a tour of the Village.

Photo credit: Matthew Johnson.

Quiet Zone

Quiet zones are deliberately positioned away from multimedia galleries and high-traffic nodes, forming acoustically calmer pockets along the circulation loop. These spaces use sound-absorbing finishes (e.g. fabric panels, carpet, perforated timber), muted lighting, and soft seating to reduce auditory and visual load, turning Pallasmaa's notion of architecture as 'a reconciliation between ourselves and the world' into a tangible sensory refuge for visitors experiencing fatigue.

Other Sensory Design Limitations

Beyond tactile and acoustic strategies, Nanjing Museum integrates temperature, smell, and material contrast into its multisensory design. Transitional spaces shift from cool, hard stone floors to warmer timber or carpet, while selected galleries introduce subtle ambient scents linked to exhibit themes, reinforcing memory and atmosphere. These layered cues echo Pallasmaa's emphasis on materiality and haptic perception, in which surfaces, textures, and environmental conditions construct a holistic experience rather than merely visual images.

Limitations Highlight Improvement Needs

Not all galleries offer tactile or non-visual alternatives and overlapping audio environments sometimes create sensory overload. These gaps reinforce the need for quiet zones, consistent tactile access, and better acoustic zoning in future inclusive museum designs [1–3]. Figure 10 presents the selected case study museum.

Nanjing Museum Through Pallasmaa's Lens

The architectural strategies at Nanjing Museum exemplify Pallasmaa's call for haptic, multisensory architecture in which materials, textures, and atmospheres speak to the whole body. Tactile pathways become 'door handles of the floor', extending its metaphor of the door handle as the handshake of the building into continuous contact that guides movement and orientation. Similarly, the calibrated lighting

and quiet rooms translate his argument that light and sound shape emotional experience, turning galleries into spaces of comfort rather than purely visual displays.

DATA COLLECTION METHODS

- *Literature and document review*: Review theoretical texts (Pallasmaa's phenomenology of senses), peer-reviewed studies on multisensory exhibitions, UNESCO/ accessibility guidelines, and site case studies (e.g., Enabling Village documentation). This builds the conceptual framework and audit criteria. Examples of tactile interpretation are shown in Figure 11.
- *Semi-structured interviews (designers and staff)*: Purpose: capture professional intentions, constraints, and tacit design knowledge about sensory and accessible strategies. Format: 45–60-minute semi-structured interviews (Eight participants were interviewed, including three architects, two museum professionals, one accessibility consultant, and two visitors with disabilities). Participants ranged from 24–56 years of age and possessed experience in museum design, accessibility, or lived experience of disability; interviews were recorded (with consent) and transcribed.
- *Analysis*: thematic coding to identify recurring principles, tradeoffs, and innovations.

Direct Observation and Sensory Mapping

- *Purpose*: Capture real-time behaviors, navigational choices, dwell times, use of tactile elements, and accessibility obstacles.
- *Method*: structured observation with a checklist, timed movement tracking (anonymized), and field notes on sensory atmospheres (lighting, echoes, and textures).
- *Deliverable*: sensory maps and sequence diagrams showing how a variety of visitors move and interact with spaces.



Figure 10. Nanjing Museum, China.

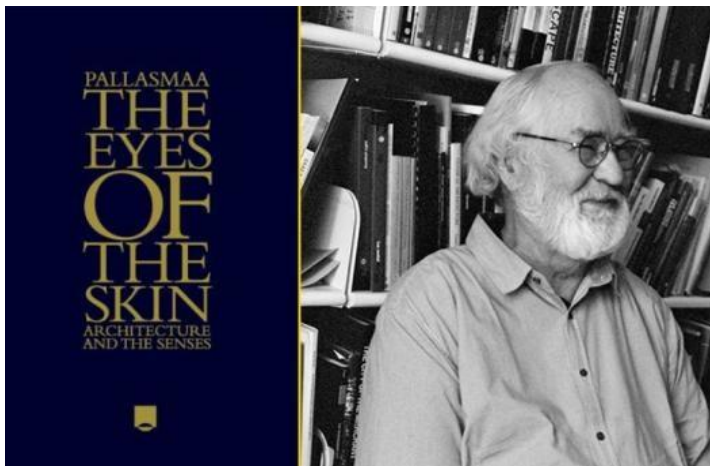


Figure 11. Book: The Eyes of The Skin by Juhani Pallasmaa.

Participatory Co-Design Workshops

Two participatory co-design workshops involving ten participants were conducted. Activities included tactile model evaluation, sensory mapping, and discussion of inclusive spatial strategies.

- *Purpose:* test and refine spatial strategies with actual users and designers; generate low-fidelity prototypes (tactile models, soundscapes).
- *Format:* 2–3 workshops per site; do hands-on activities (mapping, object exploration, tactile modelling). Capture feedback and iterate concepts.

Across two co-design workshops (10 participants), tactile model testing and sensory mapping exercises produced concrete design suggestions, such as locating quiet rooms along primary circulation routes, lowering exhibit heights for wheelchair users, and standardizing tactile wayfinding strips at key decision points. These user-generated strategies directly informed the spatial recommendations presented later in this paper.

DISCUSSION

1. *Discussion of findings versus existing literature:* The study's findings reinforce prior work on multisensory museums, which argues that tactile access and multimodal information are central to inclusion rather than optional add-ons. Consistent with Vikmane's analysis of multisensory accessibility, participants in this research emphasized that combining tactile, audio, and visual cues reduces anxiety and supports independent navigation. However, the strong demand for quiet, low-stimulation spaces adds nuance to existing literature that often focuses on adding more stimuli rather than balancing sensory load.
2. *How findings support or challenge Pallasmaa:* Field observations at Enabling Village and Nanjing Museum suggest that architecture designed for the 'multisensory mind' not only enhances perception but also social dignity, echoing Pallasmaa's claim that spaces mediate our relationship to the world through all senses. At the same time, some participants reported sensory overload in overlapping audio environments, indicating that simply adding more sensory cues can conflict with his emphasis on calm, embodied experience when not carefully zoned.
3. *Design decisions and tradeoffs:* Designing inclusive museums involves negotiating tradeoffs between exhibit conservation and tactile access, immersive multimedia and quiet refuge, and budget constraints and universal features. For instance, anti-glare display cases and controlled lighting that protect artefacts can reduce visual drama but significantly improve comfort for low-vision visitors. Similarly, dedicating floor area to quiet rooms and tactile maps may reduce space for revenue-generating galleries yet contributes directly to emotional safety and belonging for disabled visitors.

CONCLUSION

Inclusive museum design is not only about meeting accessibility standards, but also about creating spaces where every person, regardless of ability, can explore, learn, and feel a sense of belonging. This study shows that when museums use multisensory strategies, clear spatial planning, and assistive technologies, they become places that welcome diverse forms of perception and movement.

Across the research, a few ideas remained consistent. First, people with visual, auditory, and physical disabilities experience museums differently, yet they share a common need for clarity, comfort, and independence. Second, multisensory cues, such as tactile surfaces, controlled lighting, sound guides, and interactive models, help bridge sensory gaps and enrich the overall experience for all visitors. Studies on visually impaired users highlight how tactile maps, audio descriptions, and simple layouts support confidence and reduce anxiety. Similarly, global case studies show that when designers work closely with disability groups, the built environment becomes more intuitive, safer, and emotionally supportive.

This research also found that accessibility is strongest when it is embedded into the earliest stages of design, not treated as an add-on. Inclusive routes, rest areas, quiet zones, and low-stimulus spaces must

be part of the circulation logic. Feedback from field studies reveals that sensory balance—avoiding over-stimulating or confusing spaces—is essential for comfort, especially for visitors who depend heavily on one or two senses. Figure 11 summarizes the information representation methods adopted in inclusive museum environments.

Overall, this study concludes that inclusive museum design is both achievable and transformative. Creating environments that celebrate different sensory abilities results in richer storytelling, deeper engagement, and a more humane cultural experience. Inclusive museums not only remove barriers, but they create opportunities for connection, curiosity, and shared understanding [10, 11].

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