

# Quantifying Immersion: Spatial Parameters and Architectural Translation in Immersive Design

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**Abstract** - Immersive design has become an essential component of experiential design, especially in heritage environments. Despite the increasing use of immersive experiences, there remains a lack of clear architectural guidelines that define how spatial parameters influence immersion. Most existing studies focus either on technological advancements such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and projection-based systems, or on narrative and storytelling approaches, with limited emphasis on the role of architectural space itself. As a result, architects and designers often rely on intuition rather than measurable spatial principles when designing immersive environments. This research examines a quantitative methodology for immersive design by analysing spatial factors such as area, volume, viewing angles, distance, and user movement patterns, and their influence on immersive experiences. The study compares digital immersive environments, including VR, AR, MR, and 360-degree projection systems, with traditional immersive practices such as storytelling, puppetry, and folk performances. Through comparative spatial analysis, the research evaluates ergonomic sightlines, scale, enclosure, audience-performer relationships, and proxemics interactions to identify spatial characteristics that enhance immersion. The results show that digital immersive systems need larger, more regulated, and better supported environments, while traditional systems need closeness, adaptability, and group interaction to create immersion. Architects and designers must find a balance between technology accuracy and human-centred design in order to create immersive spaces that work on physical, emotional, and cognitive levels. The study concludes that a mixed architecture approach that combines traditional and digital immersive techniques can create more meaningful and interesting spatial experiences, especially in museums and heritage sites.

**Keywords** - *Experiential Design; Immersion; Immersive Architecture; Immersive Design Strategies; Narrative; Proxemics.*

## INTRODUCTION

### 1.1. Introduction

Immersive design has emerged as an important area that brings together architecture, technology, and the performing arts to create experiences that engage people physically, emotionally, and intellectually. With the growth of digital technologies such as Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and 360-degree projection environments, spatial design is no longer limited to physical boundaries. These technologies allow designers to create virtual and hybrid environments where users actively participate in narratives rather than passively observing them.

However, immersive experiences are not entirely new. Traditional forms such as storytelling, puppetry, folk performances, and community gatherings have long relied on spatial strategies like proximity, enclosure, built-unbuilt relationships, and collective participation to create engagement. These environments often achieve immersion through closeness, shared experience, and dynamic interaction between performers and audiences. As digital and traditional immersive approaches increasingly converge, there is a growing need to understand how spatial factors such as viewing angles, distances, floor area, and volumetric conditions influence immersive experiences. Whether a user is wearing a Head-Mounted Display (HMD) in a virtual environment or sitting within a circle during a folk performance, spatial qualities play a crucial role in shaping engagement and perception.

Immersion is also influenced by cultural and sensory perceptions. As noted by Edward T. Hall, architectural environments act as physical expressions of culturally shaped sensory experiences, meaning that people from

different cultural backgrounds perceive and respond to space differently (Hall). This highlights the importance of designing immersive environments that consider diverse sensory expectations, particularly in heritage and museum settings where audiences are varied and multicultural.

In addition to cultural perception, research suggests that immersive environments inspired by nature can positively influence cognitive performance, emotional well-being, and mental health. Exposure to natural or nature-inspired environments has been shown to improve mood and enhance productivity, particularly in spaces where users spend extended periods of time. As contemporary lifestyles increasingly involve indoor and screen-based environments, integrating immersive spatial strategies that draw from natural settings becomes an important design consideration.

Despite the growing popularity of immersive environments in museums, exhibitions, and educational campuses, architectural research on immersive spaces remains limited. Most existing studies focus primarily on technological advancements such as Virtual Reality, Augmented Reality, and projection mapping, while overlooking the spatial and architectural implications of immersive experiences. As a result, there is a lack of clearly defined architectural guidelines that translate immersive experiences into spatial configurations, volumetric hierarchies, and user movement strategies. This creates a gap in architectural research, where designers often rely on intuition rather than measurable spatial principles. Addressing this gap requires a quantitative understanding of spatial requirements that can support both traditional and digital immersive environments, ultimately leading to more meaningful and engaging spatial experiences. This research aims to bridge this gap by systematically analysing immersive techniques both traditional and technology-based and translating them into quantifiable architectural parameters and spatial design principles. The study therefore contributes to developing a designable framework for immersive architecture that can be applied to institutional and heritage-based campuses.

## 1.2. Immersive Design Strategies

Achieving historical accuracy in immersive environments requires a strong commitment to authenticity and careful research. One of the most effective approaches is collaboration with historians, cultural experts, and local communities, ensuring that the experience reflects multiple perspectives and grounded historical narratives. Such collaborative processes help shape not only the storytelling but also the architectural environment, soundscape, materiality, and sensory elements of the space. When these aspects are informed by credible historical sources, immersive environments become more meaningful and credible for visitors (Lab, 2024). A notable example is the *Gunpowder Plot* experience at the Tower of London, a UNESCO World Heritage Site, developed by Historic Royal Palaces. The experience integrates historically accurate costumes, sets, soundscapes, and even scent-based elements, along with virtual reality reconstructions of London in 1605. This allows visitors to experience historical events within their original spatial context, creating a layered and engaging interpretation of history (Historic Royal Palaces, n.d.).

However, technological advancement alone does not guarantee meaningful visitor engagement. Emotional connection remains central to immersive interpretation, particularly in sites associated with conflict and memory. In the context of Indian battlefields, immersive experiences must extend beyond static displays of weapons, strategies, or timelines. Instead, they should focus on the lived experiences of soldiers, leaders, and communities affected by conflict. By foregrounding human narratives, immersive environments can foster empathy and deeper understanding. Technologies such as AR and VR become most effective when used to communicate personal stories, memories, and emotional perspectives. In doing so, battlefield heritage transforms from a static physical site into a powerful experiential environment that honours courage, sacrifice, and collective memory, while enabling visitors to engage with history in a more meaningful and human-centred way.

## 1.3. Aim

To investigate the construction of immersive spaces through physical spatial configuration, multi-sensory engagement, and technological integration, ultimately translating immersive experiences into designable spatial logic.

## 1.4. Objectives

- To categorize immersive design into technology-based and traditional narrative techniques.

- To quantify the specific spatial requirements (height, radius, area, depth, spatial quality) for various immersive technologies.
- To identify the architectural implications of these quantitative needs, such as volume types and surface geometries.
- To summarise the findings of traditional and technology-based immersive environments and translate them into architectural design guidelines for creating immersive spatial experiences.

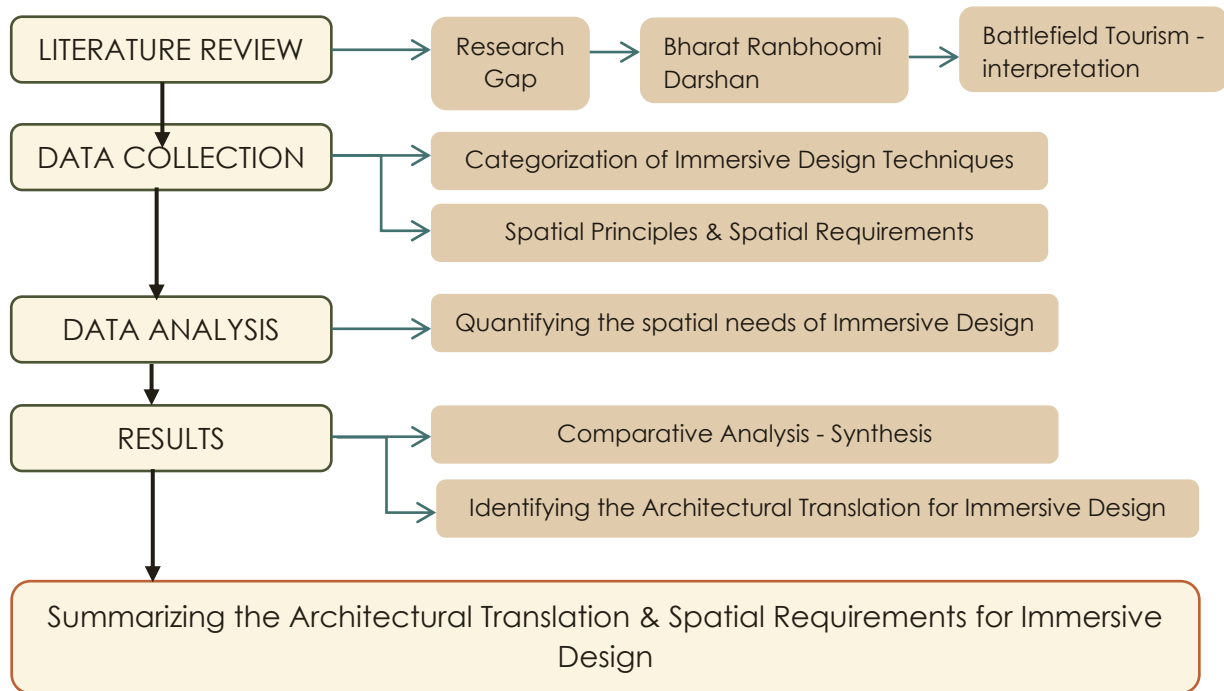
### 1.5. Scope

This research focuses on understanding immersive design from an architectural and spatial perspective. It examines how physical spatial configurations, multi-sensory engagement, and technological integration contribute to the creation of immersive environments. The study specifically investigates quantifiable spatial parameters such as user area, viewing angles, distances, movement patterns, and volumetric requirements. The scope includes both digital immersive systems such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and projection-based environments and traditional immersive practices like storytelling, puppetry, and folk performances. By comparing these approaches, the research aims to identify common spatial characteristics and translate them into architectural design considerations. The study also explores how these spatial requirements influence architectural decisions, including volume types, spatial enclosure, surface geometry, and audience-performer relationships. The overall intent is to develop architectural guidelines that can assist in designing immersive environments for museums, heritage spaces, and experiential design projects.

### 1.6. Limitations

This research is primarily theoretical and literature-based, and does not include detailed technical integration, cost analysis, or full-scale prototyping of immersive environments. While the study identifies spatial requirements, it does not test them through built experiments or real-world implementation. The spatial parameters discussed are derived from general industry standards and available literature, and may evolve as immersive technologies continue to develop. Additionally, traditional immersive practices are considered in a broader sense, without focusing on specific regional or cultural variations in depth. Furthermore, user experience and engagement are interpreted through spatial and architectural theory rather than empirical behavioural studies or user surveys. As a result, the findings provide conceptual and architectural guidance, but may require further validation through user-based research and practical applications.

## METHODOLOGY



**Figure 2.1** Methodology Chart (Author)

The methodology adopts a systematic approach to translate immersive experiences into architectural spatial requirements. The research begins with a literature review to understand immersive design, experiential architecture, and interpretation strategies in heritage environments. This stage also examines battlefield tourism and initiatives such as Bharat Ranbhoomi Darshan to identify the need for immersive interpretation in Indian historic battlefields and establish the research gap. Data is then collected through secondary literature, case studies, and documentation of immersive environments. The collected information is categorized into technology-based immersive techniques such as Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), and projection-based environments and traditional immersive practices such as storytelling, folk performances, and participatory experiences. The study then identifies spatial principles and requirements including viewing angles, user distances, spatial enclosure, height, area, movement patterns, and volumetric conditions. These parameters are quantified using available standards, ergonomic guidelines, and documented case examples. The findings are analysed through comparative evaluation between digital and traditional immersive environments to identify shared and distinct spatial characteristics. Finally, the results are translated into architectural design implications, including spatial typologies, circulation patterns, and volumetric configurations. The methodology culminates in the development of architectural guidelines for immersive environments that integrate spatial configuration, sensory engagement, and technological requirements.

## DATA COLLECTION & ANALYSIS

### 1.7. Categorization of Immersive Design

Immersive Design can be categorised into:

#### 1. Technology – Based:

- a. Extended Reality: Extended Reality (XR) is an umbrella term for every immersive technology. It includes augmented reality, virtual reality, mixed reality, digital twins, and other immersive learning technologies. This technology is an extension of reality created by adding digital counterparts in the form of inscriptions, videos, or animations (Ruks, 2023).
- b. Augmented Reality: Augmented reality means enhancing the users' real-world perception through virtual overlays. It extracts hidden features of real-world objects through object recognition and showcases informative content over it. Although in its infancy, AR has the potential to upend the way people communicate (Ruks, 2023).



**Figure 3.2** Augmented Reality (<https://www.museumnext.com/article/what-can-ar-do-to-bring-heritage-sites-to-life/>)

- c. Virtual Reality: Virtual reality is a complete turnaround of reality. It immerses a user in a virtual environment with overlays of controls like GPU, responsiveness, sound, or motion smoothing, allowing them to interact through their digital avatars (Ruks, 2023).



**Figure 3.3** Virtual Reality (<https://timesofindia.indiatimes.com/education/news/ar-vr-technologies-can-democratise-access-to-cultural-heritage-image-generated-by-ai/articleshow/122014247.cms>)

- d. 360-Degree Content: 360° content involves the integration of two or more videos in a dome-like space that's been shot from all possible angles, with 2D instructional content overlaid on top of them (Ruks, 2023).



**Figure 3.4** 360 Degree Content (<https://www.mdpi.com/2571-9408/7/5/118>)

- a. Digital Twin: A digital twin is a “carbon-copy” representation of a real-life component, structure, or process. A digital twin machine is updated using real-time tracking data and fuelled by 3D-modeling techniques to interact actively with our environment (Ruks, 2023).



**Figure 3.5** Digital Twin (<https://www.linkedin.com/pulse/digital-twins-heritage-conservation-cultural-santosh-kumar-bhoda-190gc/>)

- e. Mixed Reality: Mixed Reality (MR) tries to bind together AR and VR into an enhanced version of AR. Along with adding digital overlays of information, it develops virtual characters for the real world. Its goal is to create a deeper sense of immersion for the user than AR alone does (Ruks, 2023).



**Figure 3.6** Mixed Reality (<https://www.vi-mm.eu/project/holographic-and-augmented-reality-simulations-for-cultural-heritage/>)

## 2. Traditional Techniques:

- a. Storytelling: Storytelling is one of the oldest immersive tools used to convey history, legends, and cultural memory. Through narrative, emotion, and imagination, it allows audiences to visualize and connect deeply with events, people, and places of the past.



**Figure 3.7** Storytelling as a tradition

([https://commons.wikimedia.org/wiki/File:Indian\\_Kathakar\\_Storyteller\\_1913.jpg](https://commons.wikimedia.org/wiki/File:Indian_Kathakar_Storyteller_1913.jpg))

- b. **Songs and Ballads:** Songs and ballads serve as lyrical archives of historical events, victories, and heroism. They evoke emotion and collective memory, often transforming factual accounts into living traditions that resonate across generations.



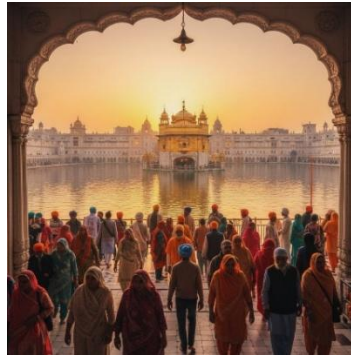
**Figure 3.8** Songs and Ballads (<https://magikindia.com/en/folk-music/>)

- c. **Puppet Shows:** Puppet theatre brings history and folklore to life through handcrafted figures, music, and dialogue. These performances depict complex narratives in an engaging, accessible way for diverse audiences.



**Figure 0.9** Puppet Shows (<https://bangalore.explocity.com/articles/the-ancient-art-of-the-rangaputhalli-puppeteers/>)

- d. **Heritage Trails:** Heritage trails are curated physical or guided routes that link important historical sites and stories. They immerse visitors in the landscape itself, allowing them to experience heritage through place, movement, and interpretation.



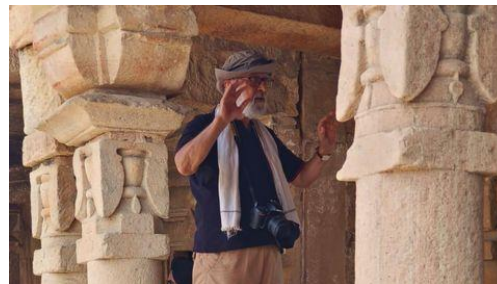
**Figure 3.10** Heritage Trails ([https://rooftopapp.com/blogs/walking-through-history-how-heritage-trails-tell-stories?srsltid=AfmBOoquYNIRSxuhX7vmFbg3OSkef\\_HKjBhuQAnc6FqIVq-E7gzfjhp](https://rooftopapp.com/blogs/walking-through-history-how-heritage-trails-tell-stories?srsltid=AfmBOoquYNIRSxuhX7vmFbg3OSkef_HKjBhuQAnc6FqIVq-E7gzfjhp))

- e. **Re-enactments:** Historical re-enactments recreate past events or battles through live performance. They combine costumes, scripts, and choreography to provide an authentic, experiential understanding of history and its emotional context.



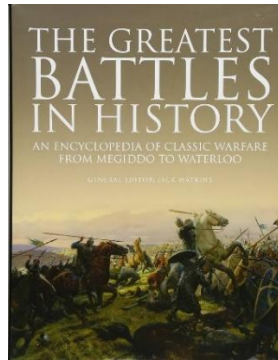
**Figure 3.11** Re-enactments of Historic Battles (<https://www.thehindu.com/society/history-and-culture/chennai-sees-battle-of-colachel-re-enactment/article24689975.ece>)

- f. **Oral Histories:** Oral histories capture lived experiences through personal testimonies, recording the voices of witnesses, descendants, and community members. They preserve the human perspective of historical and cultural events.



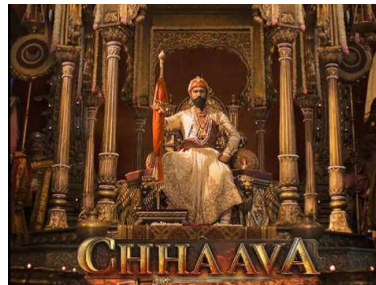
**Figure 3.12** Oral Histories (<https://www.travelandleisureasia.com/in/people/interview-with-historian-sohail-hashmi-delhi-walks/>)

- g. **Books:** Books serve as traditional sources of heritage, combining research, narrative, and imagery to document historical events and cultural evolution in an accessible, durable format.



**Figure 3.13** Books as documents for history (<https://www.amazon.in/Greatest-Battles-History-Encyclopedia-Waterloo/dp/1782745440>)

- h. Documentaries and Films: These visual media blend storytelling, imagery, and sound to reconstruct historical moments. They engage audiences emotionally and intellectually, offering both factual and interpretive insights into heritage.



**Figure 3.14** Bollywood films are widely popular as insights into history (<https://www.ndtv.com/entertainment/webstories/10-bollywood-films-based-on-indian-history-32761>)

- i. Dance: Dance interprets history and culture through movement and expression. Traditional performances often depict mythological or historical themes, transforming collective memory into a sensory, performative experience.



**Figure 3.15** Dance (<https://www.examveda.com/42nd-khajuraho-dance-festival-begins-in-madhya-pradesh/>)

*“The transition from traditional cultural history formats such as books, documentaries, or static museum displays to immersive learning experiences presents both powerful opportunities and significant challenges, particularly concerning historical accuracy” (Lab, 2024). “Virtual Reality (VR) and Augmented Reality (AR) technologies open up new possibilities by recreating historical environments, events, and cultural experiences in three-dimensional, interactive spaces. These platforms can offer users virtual field trips to ancient cities, cultural landmarks, and battlefield sites, allowing them to experience history first-hand in ways that promote deeper engagement and embodied learning” (Lab, 2024).*

**Table 1** Comparative Analysis of Traditional & Technological Immersion (*Author*)

Parameter	Traditional Immersive Techniques	Technological Immersive Techniques	Positive Implications	Negative Implications	Evolution / Transformation
<b>Storytelling</b>	Oral storytelling, guided tours, live narrators	Audio guides, AR, projection mapping, interactive screens	Technology allows multilingual, scalable, repeatable experiences	Loss of human emotion and improvisation	Live storyteller - Audio guide - Interactive AR storyteller
<b>Performance - Based Immersion</b>	Folk performances, Powada singing, theatre	Holographic performance, digital avatars, projection theatre	Can recreate historical figures and events realistically	Reduced live engagement and spontaneity	Live performers - Recorded performances - Holographic recreation
<b>Spatial Proximity</b>	Small, intimate gathering spaces	Large projection halls, VR zones, immersive domes	Larger audience capacity and scalability	Reduced intimacy and emotional connection	Intimate courtyard - Black box theatre - Immersive digital dome
<b>Visual Immersion</b>	Stage sets, murals, physical backdrops	360° projection, VR environments, LED walls	Highly realistic environments and dynamic storytelling	High energy consumption and cost	Painted backdrops - Mechanical stage sets - Digital projection environments
<b>Movement &amp; Participation</b>	Audience seated or semi-interactive	Interactive VR walking environments, motion tracking	Active user engagement and exploration	Requires technical infrastructure and maintenance	Static viewing - Interactive exhibits - Full spatial VR immersion
<b>Sensory Engagement</b>	Voice, music, physical environment	Multi-sensory immersive design (sound, vibration, projection, AR)	Stronger cognitive and emotional engagement	Risk of sensory overload	Single sensory - Multi-sensory analog - Multi-sensory digital
<b>Flexibility of Space</b>	Flexible open spaces, courtyards	Controlled environments, dark rooms, equipment zones	Greater control over environment and experience	Reduced flexibility and adaptability	Open chowk - Enclosed theatre - Controlled immersive labs
<b>User Capacity</b>	10–50 users (small gatherings)	50–200 users (immersive theatre, projection spaces)	Larger audience reach	Less personalized experience	Small gatherings - Auditorium - Immersive theatre
<b>Infrastructure Requirements</b>	Minimal (stage, seating, acoustic arrangement)	High (projectors, sensors, VR hardware, servers)	Advanced experiences possible	High cost and technical dependency	Simple platform - Stage lighting - Full digital infrastructure
<b>Cultural Authenticity</b>	High authenticity and cultural connection	Reconstructed digital authenticity	Heritage preservation and recreation possible	Risk of over-digitization and artificiality	Live heritage - Documentation - Digital heritage recreation

## 1.8. Quantitative Approach to Immersive Design

Immersive environments are not solely defined by technology, but by how space is structured to engage the body, mind, and emotions simultaneously. *“In heritage interpretation and experiential learning spaces, immersion depends on carefully calibrated spatial sequences that enable visitors to move from passive observation to active participation”* (Ahuja, 2021).

*“The perception of a space depends heavily on the user’s memory or past stimulation, which forms the foundation for how they experience the “here and now” in an immersive environment”* (Hall).

The study investigates how immersive spaces are constructed through:

- Physical spatial configuration
- Multi-sensory engagement
- Technological integration
- Traditional narrative methods

Immersion operates across three spatially driven layers:

**Table 2** Immersive Layers and their spatial translation (*Author*)

Layer	Spatial Translation
Physical	Movement, proximity, bodily engagement
Intellectual	Information absorption & interpretation
Emotional	Atmosphere, symbolism, memory triggers

**Physical Layer:** This layer focuses on the measurable spatial parameters required to create immersive environments. These include height, width, area, viewing distance, enclosure, circulation width, and volumetric conditions. These parameters help translate immersive experiences into quantifiable architectural requirements.

**Sensory Layer:** This layer examines how immersive environments engage multiple senses such as sound, light, texture, and movement. Elements such as lighting control, acoustic quality, materiality, and environmental conditions are analysed to understand how they enhance user engagement and emotional involvement.

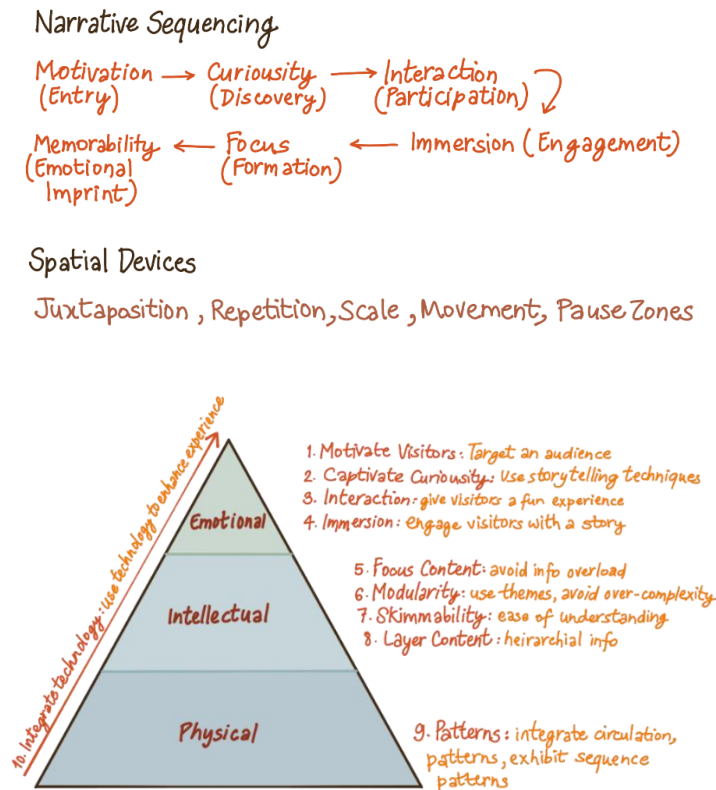
**Narrative Layer:** This layer studies how immersion is achieved through storytelling, sequential movement, and spatial transitions. Narrative sequencing, pause points, exploration zones, and emotional transitions are examined to understand how architectural spaces guide users through immersive experiences.

Together, these three layers form a comprehensive framework that enables immersive environments to be analysed and translated into architectural design principles.

## 1.9. Spatial Principles of Immersive Design

Spatial relationships, cubic volumes, and shapes must be determined in the earliest design stages to satisfy their intended purpose, as deficiencies in acoustics or lighting are costly and difficult to correct later. "Proxemics" is the study of how people use space as a way to communicate. Immersive design should be considered a deal between the user and their surroundings, where visual, auditory, tactile, and thermal elements are either encouraged or discouraged. What a person can do in a space determines

how they feel about it. For example, a room that can be crossed in two steps is very different from one that requires twenty steps (Hall).



**Figure 3.16** Narrative Sequencing & Spatial Devices (<https://www.iid.edu.in/the-circle/achieving-immersive-exhibition-design/>)

A core immersive design idea is that "walls can be a blank slate for an immersive layer," allowing the same four physical walls to transform into different environments for creativity, concentration, or relaxation. Immersive storytelling should "seamlessly blend physical and virtual space," surrounding visitors in "digital canvases" to achieve deeper emotional engagement (IDS Future Neighbourhood, n.d.).

## 1.10. Case Studies

### 1.10.1. Virasat-e-Khalsa, Anandpur Sahib, Punjab

Virasat-e-Khalsa, designed by Moshe Safdie, is an immersive museum that narrates Sikh history through spatial sequencing, light manipulation, and experiential transitions. The museum uses architecture itself as a storytelling medium rather than relying solely on digital technology. Visitors move through a carefully choreographed sequence of spaces that vary in scale, lighting conditions, and spatial compression, creating an emotional and immersive experience.



**Figure3.17** Virasat-e-Khalsa (<https://www.safdiearchitects.com/projects/virasat-e-khalsa-museum>)

The museum begins with compressed entry spaces that gradually open into large volumetric galleries, creating a sense of revelation and anticipation. Natural light is strategically introduced through skylights and apertures, enhancing the experiential quality of spaces. The spatial progression creates narrative immersion, where visitors experience history rather than simply observing exhibits.



**Figure 3.18** Virasat-e-Khalsa interior view (<https://www.safdiearchitects.com/projects/virasat-e-khalsa-museum>)

Spatial Strategies Used:

- Sequential movement
- Compressed to expanded volumes
- Light-based immersion
- Narrative circulation



**Figure 3.19** Sequential Movement (Author)

Architectural Implications:

- Immersive architecture does not always require advanced technology
- Spatial sequencing itself creates immersion
- Volume variation enhances experiential impact

### 1.10.2. Shivrushti Historical Theme Park, Pune, Maharashtra

Shivrushti Historical Theme Park is an immersive historical theme park conceptualized to narrate the life, battles, and governance of Chhatrapati Shivaji Maharaj. The project was envisioned by Babasaheb Purandare as a spatial storytelling environment rather than a conventional museum.

The theme park uses experiential architecture, landscape manipulation, and sequential storytelling to immerse visitors in Maratha history. Instead of static galleries, visitors move through fort-like pathways, recreated battle environments, immersive landscapes, and interactive installations. The spatial design mimics Maratha fort planning, where movement is indirect, layered, and exploratory. Visitors gradually encounter different historical episodes, creating an unfolding narrative experience. The architecture uses stone textures, narrow passages, elevated platforms, and lookout points to recreate the atmosphere of Maratha forts (Vastu Vidhaan, n.d.).



**Figure 3.20** Shivrushti Historical Theme Park (<https://www.vaastuvidhaan.in/Shivrushti-Pune-details.html>)

The project integrates audio narration, sculptures, life-size installations, and environmental storytelling to create immersion without relying solely on digital technology. This creates a physical immersive experience where architecture, landscape, and storytelling work together.

Spatial Strategies Used:

#### 1. Sequential Narrative Movement

- Visitors move through a chronological spatial journey
- Entry Plaza
- Introduction to Shivaji Maharaj
- Fort environments
- Battle recreations
- Governance spaces
- Cultural zones

#### 2. Maze-Like Circulation

The circulation is:

- Non-linear
- Exploratory
- Layered

This encourages:

- Discovery
- Engagement
- Spatial curiosity

### 3. Landscape as Immersive Medium

The project uses:

- Slopes
- Terraces
- Elevated viewpoints
- Dense vegetation

### 4. Multi-Scale Spatial Experience

- Different spatial scales create varied immersion:
- Small intimate storytelling spaces
- Medium interactive installations
- Large open historical landscapes

Architectural Implications:

- Immersive architecture through movement and landscape
- Physical storytelling through spatial sequencing
- Use of traditional architectural vocabulary
- Immersion without heavy digital technology



Figure 3.21 Spatial Sequencing (Author)

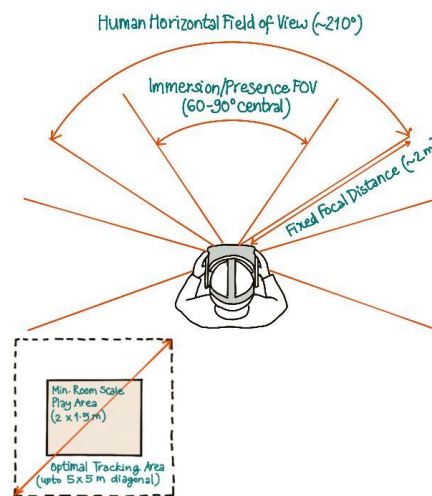
## 1.11. Analysis

### Spatial Needs of Immersive Design

The transition from traditional formats (books, static displays) to immersive learning requires a rigorous pursuit of authenticity. This involves moving from "passive observation" to "active participation" through regulated spatial sequences.

- **For Digital Tools:** The architecture must provide black-box zones for laser systems and technical catwalks for programmable lighting to maintain the illusion.
- **For Traditional Tools:** The infrastructure must support the intimacy and the visual requirements, which communicate complex narratives in accessible ways.

- 1) **VR environments** require clearly defined tracking volumes and safe movement zones. Most VR Headsets have a fixed focal distance of roughly 2 m. Human Horizontal Field of View is approximately 210 degrees. For total immersion, a digital display must cover at least 60 to 90 degrees of the user's central vision to induce presence (Mel Slater, 2016).
  - Minimum room-scale play area: 2 \* 1.5 m
  - Optimal tracking area: up to 5 \* 5 m diagonal
  - Commercial VR arenas:
    - 37 sq.m - 4 users
    - 56 sq.m - 6 users
    - 93 sq.m - 10 users
  - Approximate allocation: 9 sq.m per user (LaRocco)



**Figure 3.22** VR Headsets (Author)

Architectural implications:

- Column-free open floor plans
  - Clear safety buffer (0.5 - 1 m) around users
  - Ceiling height: more than or equal to 2.5 - 3 m
- 2) Unlike VR, **AR/MR** overlays digital content onto physical space, requiring ergonomic spatial positioning rather than fixed room dimensions. In AR, designers must place the content between 0.5 m and 5 m to avoid eye strain (Jie Fu, 2025).
    - Comfortable viewing cone: 60 degrees from eye axis
    - Interaction zone: 0.5 - 1.2 m (arm's reach)

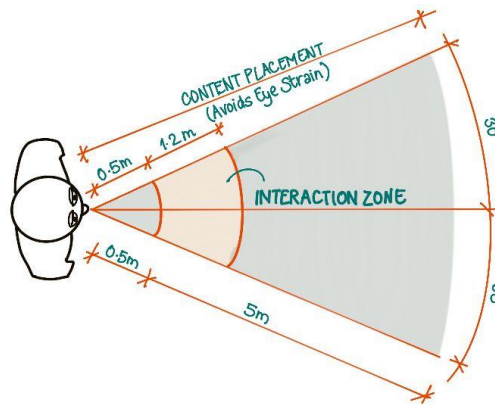


Figure 3.23 AR Zone (Author)

Architectural Implications:

- Flexible open environments
- Minimal obstruction in visual field
- Spatial layering instead of enclosure

3) **360° Dome and Projection Environments** - These signify fully immersive architectural typologies.

- Dome diameter: 6 - 8 m
- Floor area: 80 - 100 sq.m (including circulation)
- Ceiling height: 6 - 7 m minimum
- Seating distance: 1.5 - 2.2 \* dome radius
- Aisle width: more than or equal to 1.5 m (Jie Fu, 2025), (Sophia Li)

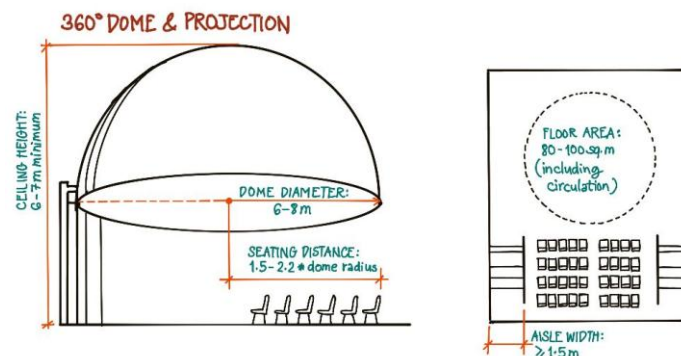


Figure 3.24 360 degree Dome & Projection Environment (Author)

Architectural implications:

- Large volumetric enclosures
- Controlled lighting (<10 lux)
- Integrated acoustic systems

4) **Projection Mapping**

- Spatial requirement depends on throw ratio

- Typical viewing distance: 10 - 40 m for large facades
- Requires unobstructed projection paths and audience zones (Sophia Li)

### 5) Storytelling Spaces

- Spatial typology: circular or semi-circular
- Area per user: 1 - 2 sq.m
- Ideal radius: 4 - 6 m for small groups (Hall)

Architectural characteristics:

- Intimate scale
- Direct eye contact
- Flexible seating arrangements

### 6) Puppet Theatre

- Stage size: 4.5 \* 2.5 m
- Audience clearance: 2.5 m
- Ceiling height: greater than or equal to 2.4 m (Michael J. Crosbie)

Architectural characteristics:

- Frontal viewing orientation
- Controlled lighting (black box condition)
- Small-scale enclosed space

### 7) Folk Dance and Performance

- Space per performer: 2 - 3 sq.m
- Performance area: flexible (10 –30 m diameter in open settings) (Michael J. Crosbie)

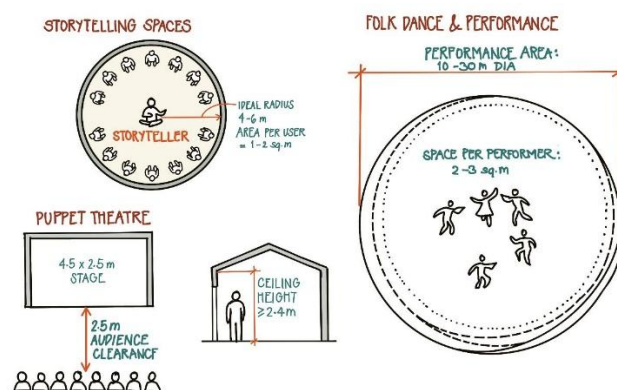


Figure 3.25 Traditional Immersive Spaces (Author)

Architectural characteristics:

- Open or semi-open layouts
- Collective participation
- Dynamic movement-based spatial use

### 8) AV Facility Ceiling Heights

- “The minimum ceiling height for projection-based facilities is dictated by the image size; if a projected image is 1.8 m high, the ceiling must be at least 3 m high to avoid sightline conflicts with the heads of seated participants” (Michael J. Crosbie).

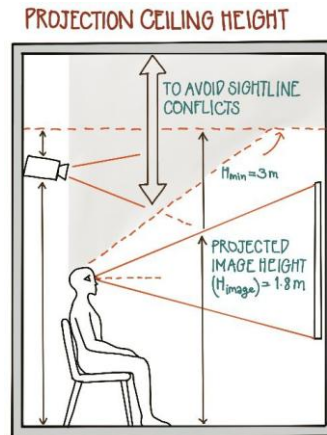


Figure 3.26 Projection Ceiling Height (Author)

### 9) Reverberation Targets

- “For high speech intelligibility in "black box" or drama-based immersive spaces, the reverberation time (RT60) should be less than 1.2 seconds. Conversely, symphonic music environments require more "live" persistence, with an RT60 greater than 1.6 seconds” (Michael J. Crosbie).



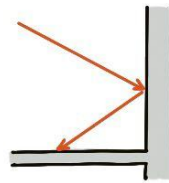
Figure 3.27 Reverberation (Author)

### 10) Sound Diffusion

- “To create an expansive feeling of "immersion in sound," designers should avoid flat surfaces and instead use convex or irregular surfaces, such as deep coffers or pilasters, to diffuse sound energy” (Egan).

### SOUND DIFFUSION FOR IMMERSION

AVOID FLAT SURFACES



USE CONVEX/IRREGULAR SURFACES

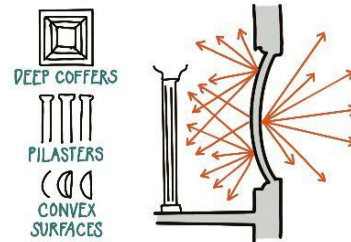


Figure 3.28 Sound Diffusion (Author)

#### 11) **"The Cube"** (The Cube - Immersive Theater, n.d.)

- Dimensions: 18L \* 11W \* 7H (inner)
- 4K or HD
- 4 walls and ceiling (Floor is optional)
- Optional HVAC
- 3 – 20 min content
- Capacity: 50 people/ upto 300 people per hour
- Optional seating
- 1 or 2 main entry/exits plus 1 emergency exit

#### 12) **Visitor Pathway** is crucial for creating an immersive design experience.

#### 13) **Display Technology Integration**

- "30" Transparent Touch OLED display to control content on a large 171" All-in-one LED flanked by two 75" portrait LCDs" (IDS Future Neighbourhood, n.d.)

#### 14) **Sustainable Materiality**

- "Immersive design should prioritize "bio-based materials" such as Mycelium bricks for screen walls and Mycelium lamps made from mushroom root structures to achieve a "zero carbon" footprint" (IDS Future Neighbourhood, n.d.).

#### 15) **Lighting Conditions**

- Controlled lighting environments are essential in immersive spaces, particularly in projection-based and digital environments. Darkened spaces enhance visual immersion, while diffused natural lighting is more suitable for traditional storytelling and participatory environments.

#### 16) **Movement Patterns**

- Immersive environments often encourage slow, exploratory movement rather than direct circulation. This requires flexible circulation paths, wider walkways, and pause points within the spatial sequence (Ahuja, 2021).

### 17) Pause and Interaction Zones

- Immersive experiences require moments of engagement and reflection. These spaces allow users to absorb information, interact with installations, and participate in narrative experiences (Ahuja, 2021).

### 18) Narrative Sequencing

- Immersion is often created through a sequence of spaces rather than a single environment. Gradual transitions from open to enclosed spaces, light to dark environments, and interactive to reflective zones enhance experiential depth (Ahuja, 2021).

### 19) Emotional Transitions

- Immersive environments rely on emotional engagement. Spatial design therefore considers scale variation, enclosure, materiality, and sound to guide emotional responses.

## RESULTS & CONCLUSION

### 1.12. Summary Tables

Table 3 Architectural Translation of Technology (Author)

Technology	Function	Spatial Requirement	Observations: Architectural Implication
Projection Systems	Visual storytelling	4.5m – 6m height, throw distance	Tall volumes, blank surfaces
Projection Mapping	Surface activation	Continuous geometry	Curved / faceted walls
VR Headsets	Personal immersion	3m x 3m user zone	Open uncluttered floor
Motion Sensors	Interaction tracking	Clear sight lines	Avoid columns
Interactive Kiosks	Participation nodes	1.5m radius clearance	Pause pockets
Directional Speakers	Narrative sound zones	Acoustic isolation	Layered partitions
Amplified Audio	Environmental sound	Distributed system	Acoustic ceiling
Holograms	Illusory depth	Dark environment	Enclosed chambers
Transparent Displays	Mixed reality layering	Controlled backdrop	Spatial depth

<b>Programmable Lighting</b>	Mood creation	Ceiling grids	Technical catwalks
<b>Laser Systems</b>	Dramatic focus	Smoke / light volume	Black-box zones
<b>Multi-Screen Systems</b>	Panoramic storytelling	Viewing arc	Curved layout

**Table 4** Spatial Requirements of Immersive Design (*Author*)

Metric	VR/AR (Digital)	Folk/Puppetry (Traditional)
<b>Minimum Active Space</b>	3 sq.m to 9 sq.m	1 sq.m to 4 sq.m (Performer)
<b>Optimal Viewing Angle</b>	90 degree – 110 degree (Horizontal)	30 degree – 45 degree (Focus area)
<b>Effective Range</b>	Infinite (Virtual) / 2 sq.m (Focal)	1.2 sq.m to 10 sq.m (Physical)
<b>Critical Density</b>	1 user per 4 sq.m	2-3 people per 1 sq.m (Standing)

### 1.13. Key Observations

- **Scale Vs Intimacy:** Digital immersive spaces require larger individual spaces due to safety and tracking constraints, whereas traditional environments achieve immersion through proximity and social interaction.
- **Viewing Angles:** VR: Approximately 100-degree field of view; Dome: 180-degree immersive field; Theatre: 30 to 50-degree optimal viewing. This indicates that visual immersion is directly proportional to spatial enclosure geometry.
- **Volumetric Requirements:** Digital immersive systems (especially domes) demand greater vertical space, unlike traditional forms which function effectively within standard room heights.
- **Flexibility vs Infrastructure:** Traditional immersive environments are spatially adaptable, while digital systems depend heavily on technical infrastructure and precision.
- **Human Scale Vs Technological Scale:** Traditional immersion is rooted in human-scale interaction, whereas digital immersion often operates at device-defined spatial limits.
- **Height Requirements:** A room's height has a much greater impact on its perceived scale than its length or width. For example, a 2.7 m ceiling may feel comfortable in a small room, that same height in a large 50 \* 50-foot immersive arena would feel oppressive.
- **Distance Zones:** There are four distance zones - Intimate (0 - 1.5 ft.); Personal (1.5 - 4 ft.); Social (4–12 ft.); and Public (12+ ft.)
- **Inclusive and Universal Design:** Future immersive spaces should be universally designed to support the widest range of human capacities, regardless of age or physical ability.

### 1.14. Spatial Hierarchy of Immersive Spaces

The analysis of immersive environments reveals that immersive architecture functions through a hierarchy of spatial scales. Different immersive techniques require varying spatial volumes, user densities, and levels of sensory engagement. Smaller intimate spaces are typically associated with storytelling, audio-based immersion, and personal digital experiences, where enclosure and proximity enhance engagement. Medium-scale spaces support interactive exhibits, projection-based environments, and participatory installations that allow controlled movement and group interaction. Large-scale immersive environments such as dome theatres, projection halls, and experiential landscapes create a sense of awe and collective immersion through volumetric expansion and visual

continuity. This spatial hierarchy becomes essential in designing immersive campuses, where transitions between intimate, interactive, and monumental spaces contribute to a layered narrative experience.

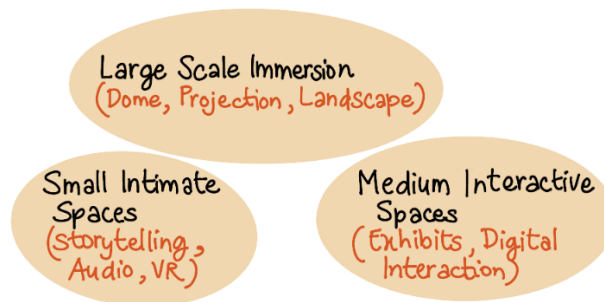


Figure 4.29 Spatial Hierarchy of Immersive Spaces (Author)

### 1.15. Spatial Typologies of Immersive Environments

Based on the comparative analysis of digital and traditional immersive techniques, several spatial typologies emerge. These typologies help translate immersive experiences into architectural design strategies.

**Black Box Immersive Spaces:** These spaces are enclosed, controlled environments used for projection mapping, holographic displays, and digital immersion. They require controlled lighting, acoustic insulation, and minimal external distractions.

**Sequential Immersive Corridors:** These spaces guide users through a narrative journey. They are commonly used in exhibitions, storytelling environments, and interpretation trails where experiences unfold gradually.

**Interactive Nodes:** These are pause points within larger circulation systems where users engage with interactive installations, displays, or performances. These nodes enhance engagement and break monotony in circulation.

**Open Immersive Landscapes:** These environments rely on natural settings, spatial layering, and environmental storytelling. Landscape elements, terrain variation, and open spaces contribute to immersive experiences.

**Hybrid Immersive Spaces:** These spaces combine traditional storytelling with digital technology. For example, a performance courtyard supported by projection mapping or augmented reality overlays.

### 1.16. Architectural Design Guidelines for Immersive Environments

Based on the synthesis of traditional and digital immersive techniques, the following architectural design guidelines are derived:

**Multi-Scale Spatial Volumes:** Immersive environments require variation in spatial scale. Large volumes are needed for projection-based immersion, while smaller spaces create intimate storytelling environments.

**Sequential Spatial Organization:** Immersion is achieved through spatial sequencing. Gradual transitions between spaces enhance narrative flow and user engagement.

**Flexible Circulation Patterns:** Immersive spaces benefit from exploratory movement. Non-linear circulation paths allow users to engage with experiences at their own pace.

**Hybrid Technology Integration:** Traditional immersive practices can be enhanced using digital technology. Spaces should therefore be designed to accommodate future technological integration.

**Controlled Environmental Conditions:** Lighting, acoustics, and materiality play a crucial role in immersive experiences. Architectural design must consider these elements to create effective immersive environments.

**Pause and Reflection Spaces:** Immersive environments require areas for reflection and interaction. These spaces help users absorb information and enhance experiential depth.

The findings from immersive techniques can be translated into architectural strategies through a systematic framework. Each immersive medium generates specific spatial requirements that influence architectural form, circulation, and spatial organization. Virtual Reality requires enclosed, controlled environments with minimal distractions, leading to compact black-box spaces. Projection mapping environments demand column-free volumes and continuous surfaces to maintain visual coherence. Traditional storytelling spaces rely on sequential movement and layered spatial transitions. By mapping immersive techniques to architectural responses, immersive architecture can be designed as a structured spatial system rather than a purely technological installation. This translation allows immersive experiences to become embedded within architectural design rather than applied as superficial additions.

## 1.17. Conclusion

This research investigates immersive environments as architectural experiences shaped through spatial configuration, sensory engagement, and narrative sequencing. The study identifies that immersive design is not limited to digital technologies but also exists in traditional storytelling, performances, and participatory environments. By categorizing immersive techniques into technology-based and traditional approaches, the research establishes a comprehensive understanding of immersive environments.

The study further quantifies spatial requirements such as viewing angles, distances, height, area, and volumetric conditions. These measurable parameters allow immersive experiences to be translated into architectural spatial requirements. The comparative analysis reveals that digital immersive environments typically require larger, controlled volumes, while traditional immersive environments rely on intimacy, flexibility, and narrative sequencing. However, both approaches share common spatial characteristics such as enclosure, controlled movement, and multi-sensory engagement.

Based on this synthesis, the research develops architectural design guidelines and spatial typologies for immersive environments. These include black-box immersive spaces, sequential corridors, interactive nodes, open immersive landscapes, and hybrid immersive environments. These typologies demonstrate how immersive experiences can be translated into architectural design strategies.

The findings also highlight the importance of hybrid immersive environments that combine traditional storytelling with digital technology. Such environments create richer experiences by integrating spatial narrative with technological enhancement (IDS Future Neighbourhood, n.d.).

This research contributes to architectural practice by establishing quantifiable spatial guidelines for immersive design. These guidelines assist architects in designing environments that integrate spatial configuration, sensory engagement, and technological requirements.

The study is particularly relevant to heritage interpretation and immersive tourism, where architectural spaces can enhance experiential understanding of history. By translating immersive experiences into architectural logic, the research provides a framework for designing immersive campuses, interpretation environments, and experiential heritage spaces. Future research may further explore empirical user studies, technological advancements, and region-specific immersive practices to refine these architectural guidelines.

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