Role of Information and Communication Technology in Shaping Modern Museum Interiors

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Abstract

This study explores the integration of Information and Communication Technologies (ICT), specifically Augmented Reality (AR) and Virtual Reality (VR), in museum interior design. Through literature studies and case studies, this paper highlights how these technologies enhance visitor engagement, accessibility, and storytelling. The major concern is how spatial planning requirements for ICT are incorporated, offering design insights for immersive, interactive exhibitions. The research provides a framework for incorporating digital innovations into museum spaces for immersive experiences.

Keywords: Information and Communication Technology (ICT), Augmented Reality (AR), Virtual Reality (VR), Museum Interiors, Immersive Experiences, Spatial Planning, Interactive Exhibitions, Digital Storytelling, Visitor Engagement, Cultural Preservation.

1 CHAPTER 1- INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

1.1.1 INFORMATION AND COMMUNICATION TECHNOLOGY

- ICT means the use of computer-based technology and the Internet to make information and communication services available ina wide range of users.
- ICT Is a Hardware and Software that enable society to create, collect, consolidate and communicate information in a multimedia format and for various purposes.
- The term ICT includes any communication device or application, encompassing, radio, TV, cellular phones, computers and network, hardware and software, satellite systems and so on, as well as the various services and application associated with them. (Reena,2021)

Figure 1(Source Medley . 2019)

1.1.2 AUGMENTED REALITY

- AR often involves using a smartphone to superimpose images or videos onto a representation of the actual surroundings (GeeksforGeeks, 2024).
- Allowing interaction between the user's physical and digital worlds,
- The overlaying image allows them to establish new connections or interactions.

Figure 2(source: M. A., 2009)

1.1.3 VIRTUAL REALITY

- VR produces a completely immersive experience with the use of a headset and digital imagery to immerse the viewer in a virtual environment.
- Using a headset, the user engages with a fully virtual environment in VR as well as a controller.
- In virtual reality, a sensory experience is produced by encouraging and deceiving the senses into communicating with real world (GeeksforGeeks, 2024).

Information and communication technology have revolutionized the interior design industry by offering immersive, interactive, and highly customizable experiences to the user. The rapid advancement of this technology has improved the ability to visualize the final outcome.

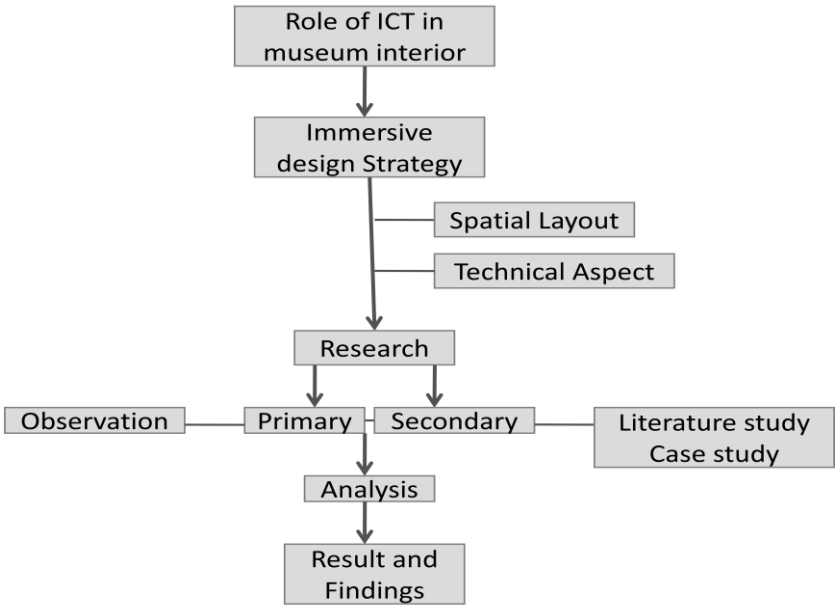
1.2 AIM

To investigate how we can integrate Information and Communication technologies with interior design in museum spaces.

1.3 OBJECTIVES

- To Understand the evolving technology and their applications in context of museums.
- Examine current museums that have effectively incorporated information and communication technology into their environments to learn about best practices and potential drawbacks.
- Analyzing how 3D Screens, VR and AR can influence the spatial planning of exhibitions and how physical environments can be augmented by digital elements.

1.4 METHODOLOGY



SCOPE OF THE STUDY

To understand the spatial layouts that maximize the use of available space for seamless integration of digital technologies such as screens, AR, and VR installations.

1.5 LIMITATIONS

- This study is limited to the spatial layout required for incorporating ICT.
- Due to time constrain this study will not cover the user experience and impact of ICT in learning.

2 CHAPTER 2– LITERATURE REVIEW

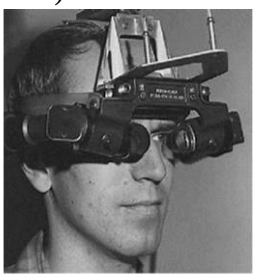
2.1 UNDERSTANDING ICTs (AUGMENTED REALITY AND VIRTUAL REALITY)

Augmented Reality (AR) and Virtual Reality (VR) are transformative technologies that offer immersive experiences across various fields. While both technologies create enhanced digital interactions, they differ fundamentally in blending digital and physical environments (Yung & Khoo-Lattimore, 2019).

With the integration of other ICTs AR and VR has facilitate interaction using digital kiosks and mobile applications through storytelling, virtual tours and 3D visualizations. The use ICTs are making museums more accessible, inclusive, interactive and appealing environment to the users and inchance there overall experience.

2.1.1 HISTORICAL BACKGROUND OF AR AND VR

The origins of AR and VR trace back to the 1960s. Ivan Sutherland's "Sword of Damocles," the first head-mounted display, set the stage for immersive experiences (Sutherland, 1968).



Staff ,2022
Sword of Damocles

Luna ,2021
Sensorama

Figure 3(source:stiff,2022)

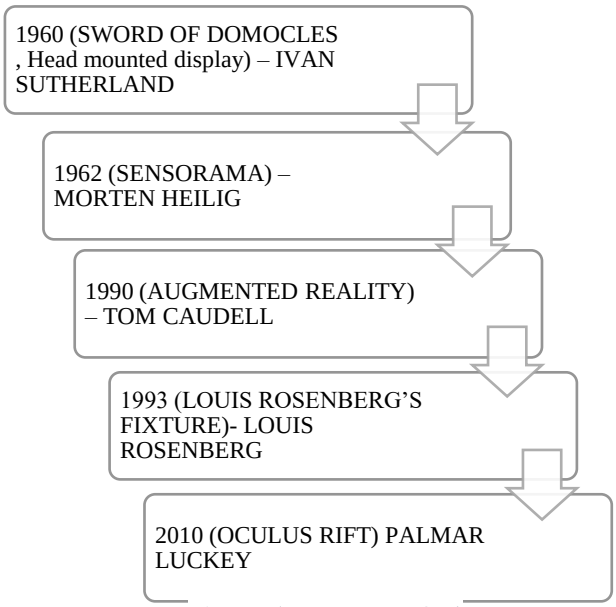


Figure 4(source;Luna,2021)

Meanwhile, Morton Heilig's "Sensorama" sought to create multi-sensory environments, further influencing the development of VR technologies (Heilig, 1962).

The term "augmented reality" was coined in the early 1990s by Tom Caudell to describe systems enhancing real-world tasks (Caudell & Mizell, 1992) (Jonathan, 2018).

The 1990s saw significant advancements, including Louis Rosenberg's Virtual Fixtures, which showcased AR's potential in enhancing human performance (Rosenberg, 1993). Jaron Lanier's VPL Research contributed crucial innovations in VR, though early gaming attempts like Sega VR faced challenges in market adoption (Sullivan, 1995).

(Presence History: How a Parachute Accident Helped Jump-start Augmented Reality – ISPR, 2022)

Louis Rosenberg's Fixture

Figure 6(source:ISPR,2022)

Figure 5(source:Dingman,2019)

Oculus Rift

In the 2000s, the advent of mobile devices catalyzed the growth of AR applications, with platforms like Layar and Wikitude enhancing user interaction with digital content (Billinghurst et al., 2015). The 2010s marked a resurgence of VR, spurred by the Oculus Rift and similar headsets, making immersive experiences accessible to consumers (Jonathan, 2018). (Dingman, 2019)

2.1.2 AUGMENTED REALITY

Figure 7(Source;wemblykens,n.d)

Augmented Reality (AR) involves overlaying digital information—such as images, sounds, and other sensory enhancements—onto the real-world environment, typically through a device screen or wearable technology.
This enables users to see the real world with computer-generated images layered on top, providing context or interactive elements that respond to real-time surroundings (Guttentag, 2010; Yung & Khoo-Lattimore, 2019).

For instance, mobile applications like mTrip use AR and geolocation to user with relevant, context-sensitive information about nearby attractions, enhancing engagement without removing users from their physical environment (Yovcheva, Buhalis, &Gatzidis, 2012).

To deliver AR experiences, devices must have cameras and sensors capable of interpreting physical space.

- Tracking and Alignment:
  GPS, gyroscopes, or computer vision track the user's location and orientation, allowing accurate placement of virtual content (Jung, Chung, &Leue, 2015).

- Information Integration:
  AR systems access databases to display real-time virtual images or text relevant to the user's environment.

- Display:
  Virtual content overlays real-world views via devices like smartphones or tablets,enhancing sensory experience without full immersion (Guttentag, 2010; Yung & Khoo-Lattimore, 2019).

2.1.2.1 MECHANISMS INVOLVED IN AUGMENTED REALITY

- Hardware:
  Essential AR hardware includes displays (smartphones, tablets, smart glasses, head-mounted displays), sensors (cameras, motion sensors), and processors (CPUs and GPUs) that enable real-time rendering of digital content (Rauschnabel et al., 2019).

- Software:
  AR applications are developed using software platforms such as ARKit (Apple) and ARCore (Google), that can augment virtual objects to surfaces in the real world when seen through the phone's camera. (Huang et al., 2019).

- Tracking and Registration:
  Accurate tracking is crucial for AR. Marker-based tracking uses predefined images to anchor content, while marker less tracking employs GPS and computer vision to place digital objects without physical markers (Huang et al., 2019).

2.1.3 VIRTUAL REALITY

Virtual Reality (VR) immerses users in a fully computer-generated environment, detaching them from the physical world. VR's defining elements—visualization, immersion, and interactivity—create a realistic simulation of senses like sight, sound, and touch, allowing users to engage with virtual surroundings (Guttentag, 2010; Cruz-Neira et al., 1992).
This makes VR particularly useful, where prospective users can virtually explore destinations before visiting, enhancing their decision-making and engagement with the location (Williams & Hobson, 1995).

Figure 8(source: cliff,2021)

2.1.3.1 MECHANISM INVOLVED IN VIRTUAL REALITY

- Head-Mounted Displays (HMDs): Devices like PlayStation VR by Sony, Oculus Rift and HTC Vive immerse users visually in a digital space by isolating them from their real-world surroundings (Jonathan, 2018).
- Input Devices: Controllers, gloves, or motion sensors allow users to interact with virtual elements.
- Computing Power: High-performing processors and graphics cards are essential for rendering realistic, real-time simulations, ensuring a seamless experience (Yung & Khoo-Lattimore, 2019).

While AR and VR both the technology offers novel interaction, their applications and mechanics differ significantly. AR relies on accessible devices like smartphones and tablets, layering digital enhancements onto real-world experiences (Yovcheva et al., 2012)
VR, on the other hand, fully immerses users in a simulated environment, ideal for exploring locations or scenarios which are otherwise inaccessible.

2.2 USE OF TECHNOLOGY IN MUSEUMS

The integration of all the ICTs as Augmented Reality (AR) , Virtual Reality (VR)and other 3D visualization screens in museums has modernized presentations and make cultural narratives more interactive (Ribeiro et al., 2024).
These technologies offer new ways to engage visitors by enhancing traditional exhibits with immersive digital elements. Museums have traditionally functioned as preservers of cultural artifacts, but AR and VR now allow them to create environments that provide deeper context of understanding.

2.2.1 APPLICATION OF AUGEMNTED REALITY (AR) IN MUSEUMS

2.2.1.1 AR for Artifact Interaction and Navigation

AR enhances the way visitors interact with physical exhibits by overlaying digital reconstructions and detailed historical information on artifacts. Studies indicate that AR can make exhibits more engaging by adding layers of context—visitors can virtually view artifacts in their original settings or witness historical events as if happening before them.

Figure 9(source:jons,2020)

For example, the British Museum's "A Gift for Athena" game uses AR to direct attention to specific artifacts, encouraging an interactive experience .

2.2.1.2 AR in Indoor Navigation

In museums with complex layouts, AR-based navigation systems provide visual cues, helping visitors locate specific exhibits while gaining contextual information.

The D. Diogo de Sousa Museum in Portugal, for instance, has integrated AR for both artifact interaction and indoor navigation, allowing users to receive guidance .(Ribeiro et al., 2024).

2.2.1.3 Gamified AR for Enhanced Learning Experiences and making it more interesting

AR in museums often includes gamification elements, like quizzes and challenges, which foster active participation. The integration of game mechanics in AR encourages visitors to explore and engage with exhibits on a deeper level, appealing especially to younger audiences.

The case of the British Museum's AR experience exemplifies this approach, transforming the museum visit into an interactive quest where learning and engagement are combined (Özgül &Fethiye, 2021).

Figure 10(source:lioen,2019)

2.2.2 APPLICATION OF VIRTUAL REALITY IN MUSEUMS

2.2.2.1 Virtual Reality for Remote Accessibility and Inclusive Experiences

VR allows museums to transcend physical limitations, offering virtual tours that make cultural experiences accessible to remote or physically limited visitors. By creating virtual environments, museums can reach a wider audience.

For instance, the Louvre's "Mona Lisa: Beyond the Glass" project immerses viewers in a VR environment that brings them "inside" the Mona Lisa's world. This experience not only offers a new perspective on the artwork but also connects viewers with the historical context in an emotionally engaging way (Jusseaux, 2020).

Figure 11(source: jusseaxe,2020)

The VR initiatives at the Kempegowda Museum in India further showcase how VR brings local heritage to a global audience, allowing users to explore ancient Bengaluru through a realistic virtual environment (Rao, 2024).

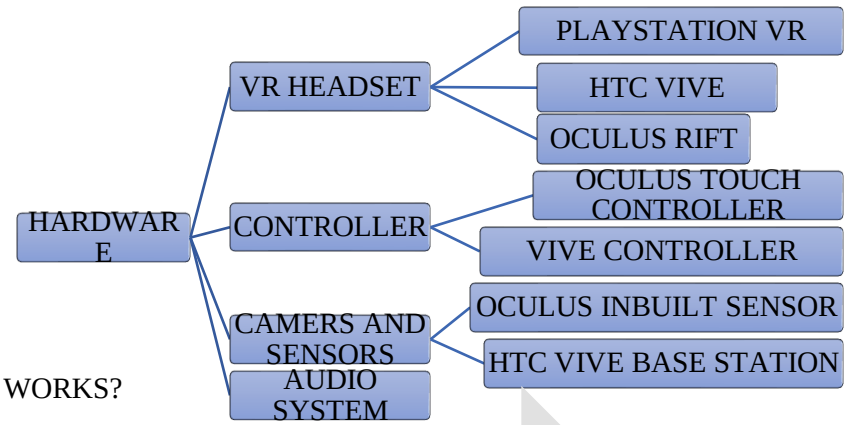
2.2.2.2 VR as a Tool for Digital Preservation and Educational Storytelling

In museums, VR serves as a preservation method by digitally archiving artifacts and sites that may be inaccessible or at risk of degradation. Virtual representations of archaeological sites or cultural landmarks provide visitors with experiences of historical spaces that may no longer exist physically.

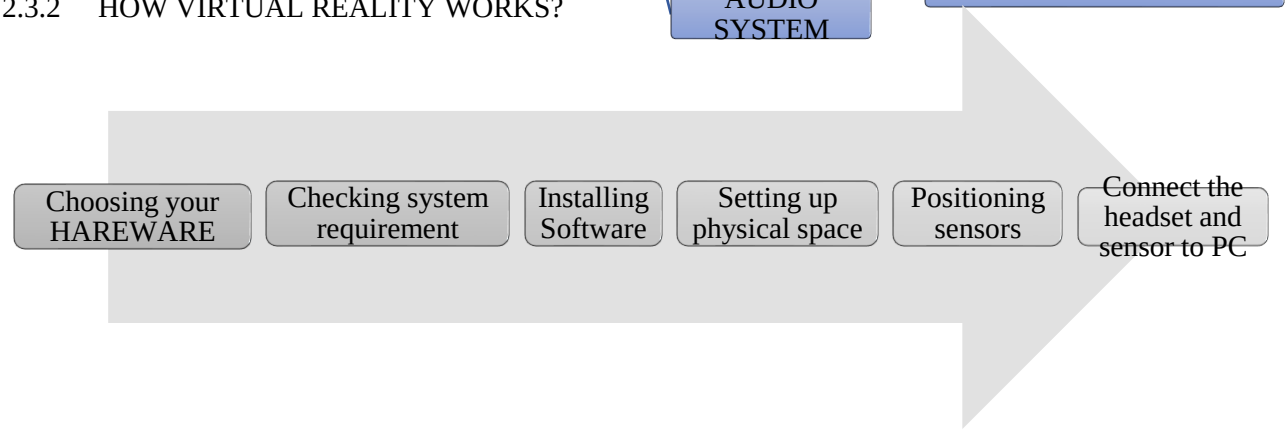
The D. Diogo de Sousa Museum uses VR to create a "Digital Twin" of its exhibits, enabling remote visitors to explore the museum in a virtual setting while learning about its historical artifacts.

2.3 WORKING MECHANISM OF VIRTUAL REALITY

2.3.1 CORE ELEMENTS OF VR



2.3.2 HOW VIRTUAL REALITY WORKS?



2.3.2.1 Hardware Components

- VR Headsets:

The most essential hardware for VR experiences in museums. Headsets like Oculus Rift, HTC Vive, or standalone VR headsets are used to immerse visitors in a virtual environment. They come with sensors and screens that provide a stereoscopic display, creating a 3D effect.

1) PLAYSTATION VR BY SONY:
This headset provide nine LEDs that are tracked by the play station camera to locate user's head orientation and can also track hand movement (Jonathan, 2018)

2) THE HTC VIVE:
This is the most advanced headset that features 70 sensors. It require powerful computers to run its dual full HD screen. It supports room scale of 4.6sqm so that you can walk around.

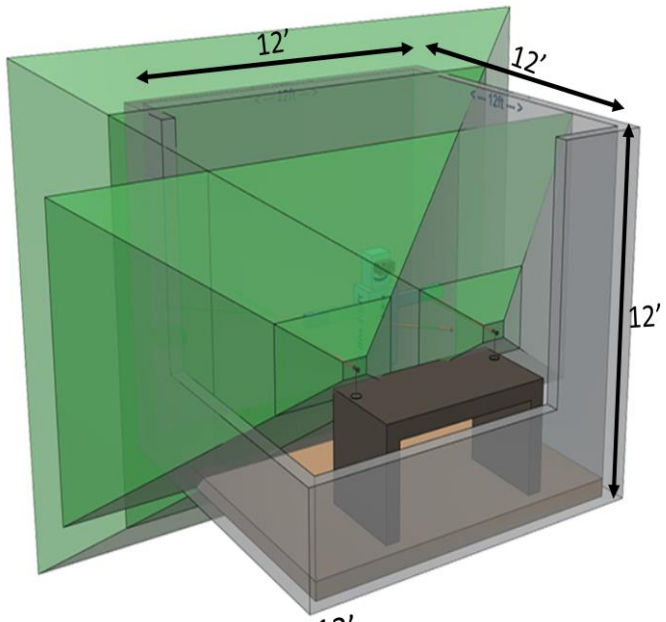
2.3.3 ROOM SCALE FOR SETTING UP THE VR

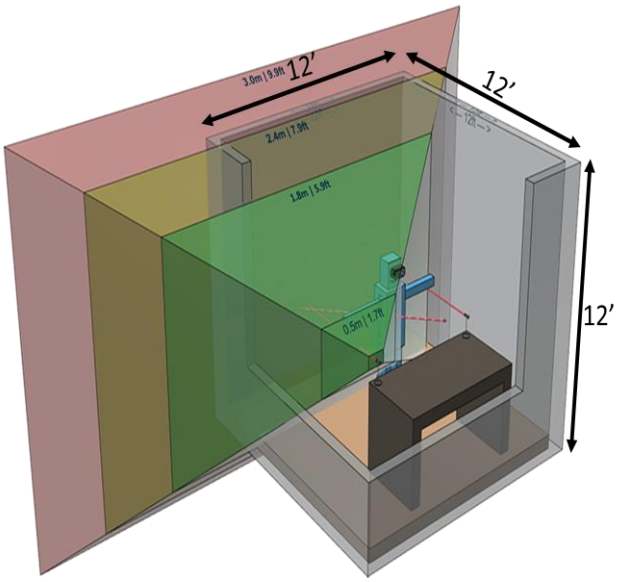
We will stick to the basic three-sensor setup. By building upon that setup and exploring new configurations, you'll improve room coverage and better prevent occlusion (things like your desk or furniture blocking the view of the sensors).

- ROOM AREA – 144sqft

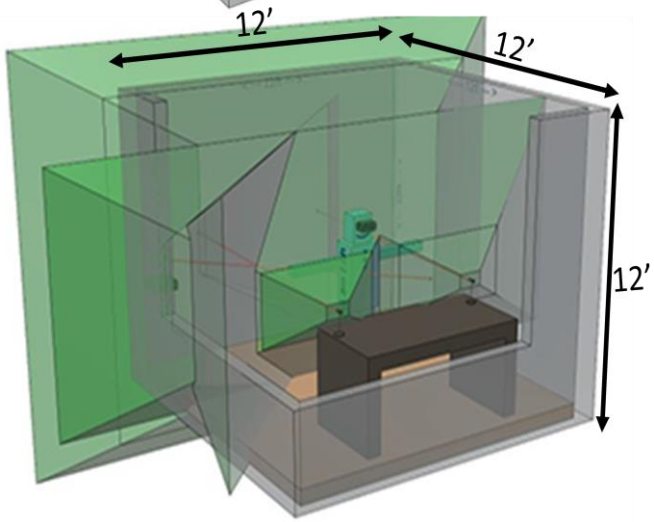
- DISTANCE OF SENSOR FROM FLOOR – 3’-6’
- FIELD OF VIEW -100 degrees horizontal and 75 degrees vertical

SINGLE SENSOR
Ideal tracking -6’
Good tracking -8’
Worst tracking -10’





- DISTANCE FROM FLOOR – 8’ at corners of the room
- FIELD OF VIEW - 45-degree angle Downwards.



TRIPLE SENSOR
Ideal tracking -12’

2.4 INFERENCE

Based on the literature review here are the inferences related to spatial layout and requirements for installing ICTs in museums, focusing on flow and navigation, room scale and display angles:

For a viewing screen the ideal ratio of the screen is 16:9 (Most immersive setups, such as projection screens, virtual reality headsets, and large-format displays, are designed around the 16:9 aspect ratio). This ratio is recommended and authorized by many international authorities as ITU (International Telecommunication Union) and SMPTE(Society of Motion Picture and Television Engineers)

2.4.1 ROOM AREA AND SCALE FOR PROJECTION SCREEN

2.4.1.1 MINIMUM ROOM AREA = 144 sqft (For instance 12'*12'), approx. 13.4 sqm

According toSMPTE recommended angle of 30° and using height- distance formulae

Viewing distance = Screen height*1.5

For instance = According to the ratio of 16:9, if the screen with is 10'wide and 5'8" high, then minimum viewing distance would be approximately 9'

Minimum viewing distance- 9'

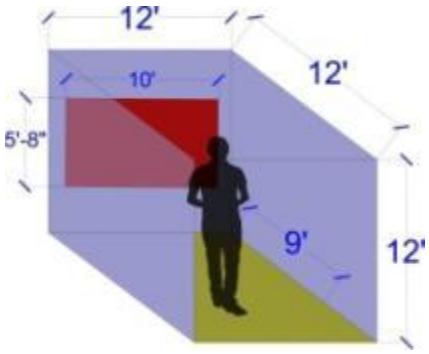


Figure 12(source:author)

2.4.2 ROOM AREA AND SCALE FOR VR SCREEN

2.4.2.1 MINIMUM ROOM AREA = 144 sqft (For instance 12'*12'), approx. 13.4 sqm

According to field of view required for setting up VR i.e100° Horizontal and 75° Vertical and using height- distance formulae

Viewing distance = Screen width * 0.56

For instance = According to the ratio of 16:9, if the screen with is 10'wide and 5'8" high, then minimum viewing distance would be approximately 5'- 6'

Minimum viewing distance- 5' -6'
5 to 6 feet is ideal for screens about 10 feet wide.

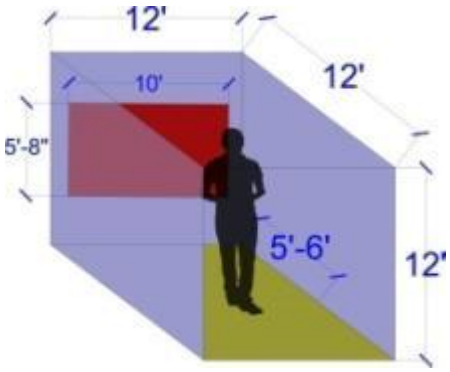


Figure 13(source;author)

2.4.3 DISPLAY FOR AUGMENTED REALITY

- The display screen for AR should be small or compact enough to scan through our laptops and tablets.
- The display should be of high resolution so that it can easily overlay the content.

2.5 INFERENCE TABLE

S.NO	TITLE NAME	PUBLISHER NAME	PUBLISHING YEAR	INFERENCE
1	Virtual reality and augmented reality displays: advances and future perspectives	IOP Publishing	2021	Defines the system requirements based on visual and wearable comfort.
2	Augmented Reality and Virtual Reality	Kent State University	2018	Introduction to AR and VR and its technical aspects.
3	A Systematic Literature Review on Virtual Reality and Augmented Reality in Tourism Research	Griffith University	2019	AR and VR bring to the light to realism, thus helpful in fostering tourism.
4	The Role of AR in Enhancing	Elsevier	2021	AR improves accessibility by

	Museum Accessibility			providing customizable digital layers that cater to diverse visitors' needs.
5	Virtual Reality as a Tool for Curating Museum Interiors	MIT Press	2023	VR enables curators to design flexible, adaptive spaces that can change exhibits without physical alterations.
6	Exploring Cultural Heritage with AR: Redefining Museum Space.	Journal of Cultural Heritage Studies	2022	AR helps museums recreate and visualize lost or distant cultural heritage,expanding exhibit possibilities.
7	Spatial Augmented Reality: Merging Real and Virtual Worlds	ACM SIGGRAPH 2005 Courses	2005	This work presents spatial AR, focusing on techniques that merge physical and virtual elements. It discusses applications in art, design, and interactive installations, showcasing the creative potential of AR.
8	Augmented Reality for Maintenance and Repair: A Literature Review	Journal of Manufacturing Systems	2019	This literature review analyzes how AR improves accuracy and efficiency, thereby reducing downtime and operational costs
9	A Study of Markerless Augmented Reality Technology	Journal of Ambient Intelligence and Humanized Computing	2019	This study focuses on markerless AR, discussing its technological advancements, applications, emphasizing the flexibility and adaptability of AR systems.
10	A Survey of Augmented Reality	Foundations and Trends in Human-Computer Interaction	2015	This survey highlights advancements in AR technologies, categorizes existing applications, and discusses interaction techniques.
11	VR, AR, gamification, and AI towards the next generation of systems supporting cultural heritage	ACM Conference on 3D Web Technology	2024	This provides us insight on how AR, VR, and AI enhance visitor engagement and accessibility in museums. He use the D. Diogo de Sousa Museum as a case study, showcasing how AR and VR can be used for artifact interaction in museum .
12	Innovative Approaches to Cultural Preservation: Integrating AR/VR Technology in Kempegowda Museum	International Journal for Multidisciplinary Research (IJFMR)	2024	This paper tells us about the Kempegowda Museum's integration of AR and VR to create immersive experiences tied to Bengaluru's cultural heritage.
13	Virtual Reality and	ICT Tools and Applications	2021	The role of AR and VR in

	Augmented Reality Technologies for Accessibility in Museums	for Accessible Tourism		improving museum accessibility, especially for individuals unable to visit in person. By enabling virtual tours and augmented interaction with exhibits.
14	Virtual Reality in Museums: Exploring the Experiences of Museum Professionals	Applied sciences	2020	It emphasizes VR's potential to enhance engagement and interpretation within exhibitions but also highlights challenges and strategic integration. It concludes with recommendations for more effective VR application in museums to foster engagement with cultural heritage
15	Virtual Reality in Education: A Tool for Learning in the Experience Age	International Journal of Innovation in Education, Inderscience Enterprises Ltd	2018	The paper discusses VR's effectiveness in providing immersive learning, aiding the development of 21st-century skills and creativity, and proposes further research into VR's role in interactive educational environments
16	The complete guide to VR and 360 degreephotography by Jonathan Tustain	Octopus publishing group	2017	This book will introduce you to a whole spectrum of VR possibilities and its evolution. This books tells us sbout how this whole technology came into working and the related parametres.

3 CHAPTER 3 (CASE STUDY)

3.1 VIRASAT- E –KHALSA

3.1.1 INTRODUCTION

Virasat -e-Khalsa, located in Anandpur Sahib, Punjab, is more than just a museum; it's a tribute to Sikhism's rich heritage and culture. Opened in 2011, this impressive building has become a key site for exploring Sikh history, spirituality, and identity, drawing visitors from around the globe.

This museum complex was awarded to the Israeli American architect Moshe Safdie with Ashok Dhawan as the local Associate Architects and the interior display of this museum was done by Ar. Amardeep Behl.

The brief that was given to Architects and designer apart from designing the museum was "how we can design a museum without artefacts, based completely on experiences"

3.1.2 PLANNING OF THE MUSEUM

The whole heritage centre is a complex divided into 3 parts – eastern and the western block which is connected by a 540 ft. Bridge. So, when looking at the zoning broadly the western and eastern complex consists of closed functions and the central complex consists of recreational facilities such as the café under the bridge and the Open Air theatre.

3.1.2.1 Eastern complex:

A 540 ft. from the western complex provides pedestrian access to the eastern complex, which comprises of – permanent exhibitions presenting Sikh history, religion, and culture.

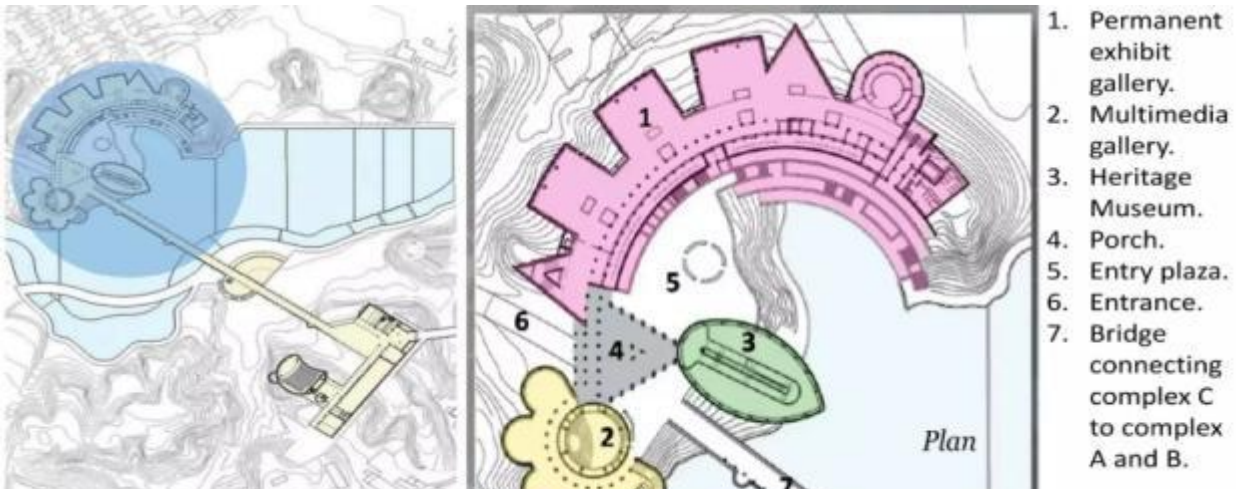


Figure 14((Parihar, 2020))

3.1.3 TECHNOLOGIES INTEGRATED

3.1.3.1 AUDIO-VISUAL INTEGRATION

The museum has large-scale projections and synchronizes audio-visual systems to tell stories about Sikh history and culture.
They are particularly used in galleries where visitors can significantly learn and experience historical events. Audio-visuals allow visitors to watch dynamic storytelling sequences, blending video, narration, music, and ambient sound to create immersive environments.

3.1.3.2 AUGMENTED REALITY

AR is used in interactive displays where visitors can access additional layers of information by scanning specific artifacts or exhibits.
They are installed at the entrance and in all the galleries, which allows deeper understanding and engagement of all the historical events.
Visitors can use devices like smartphones or tablets to scan the QR codes and explore additional content related. They can also visualize the event on their gadgets. Visitors can choose which stories or artifacts they wish to learn more about, controlling the experience at their own pace.

3.1.4 DESIGN FEATURES

3.1.4.1 Permanent Exhibit Gallery

- This consist of 6 galleries that cover the lives of Guru Hargobind, Guru Har Rai, Guru Harkrishan, Guru Teg Bahadur, Guru Gobind Singh and Gurta Gaddi.
- The museum uses high-end audio-visual technology to narrate key moments of Sikh history. Each gallery is equipped with large-format projectors, dynamic lighting systems, and immersive soundscapes.
- These experiences recreate entire environments, allowing users to experience 180-degree views of important historical scenes

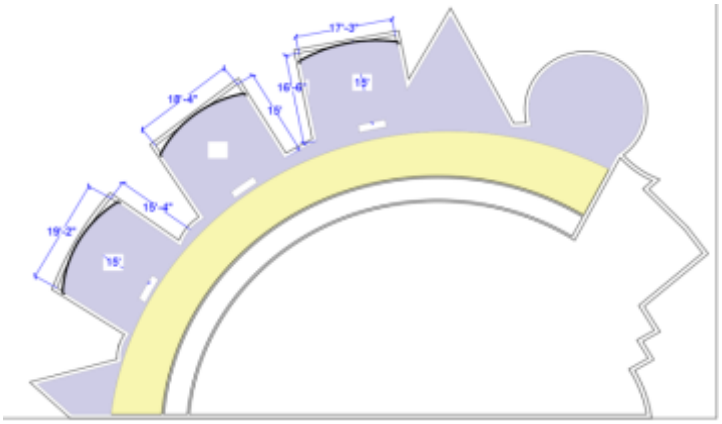
Figure 15(source;author)

Room Area = 270 – 300 sqft

Distance from visual display screen to setting area 15’

Distance from multiple projected screen to standing platform = 11’

Height of the Exhibition galleries = 15’



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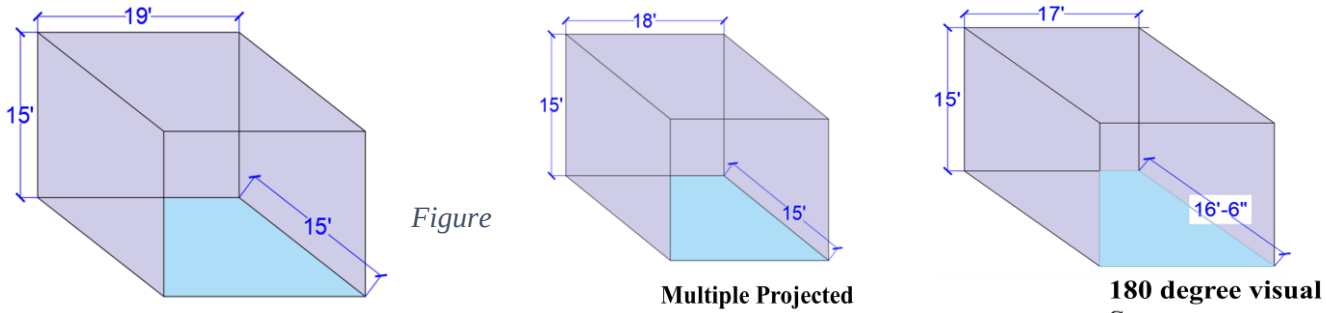
Corridor width = 8’-3”



(Gallery 1)

Figure 17(source;author)

Multiple Projected Screen (Gallery 2)

180 degree visual Screen (Gallery 3)

Figure 16(source;author)

3.1.4.2 Multimedia gallery:

- The museum features advanced audio-visual presentations that create immersive experiences for visitors.
- Each gallery is designed to narrate Sikh history through a blend of historical narration, music, and imagery.
- This multimedia screen approach helps make the stories of the Sikh Gurus and significant events accessible and engaging for a wide audience.
- Audio-visual storytelling techniques to depict the teachings and principles of the Sikh Gurus, blending digital displays with traditional artistic techniques like hand-painted murals.

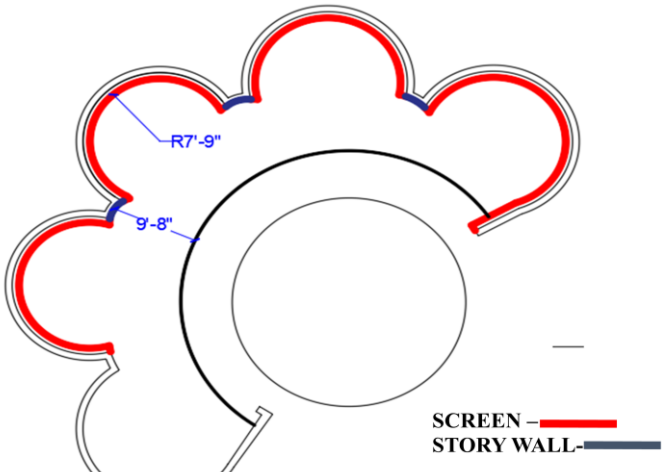


Figure 19(source;author)

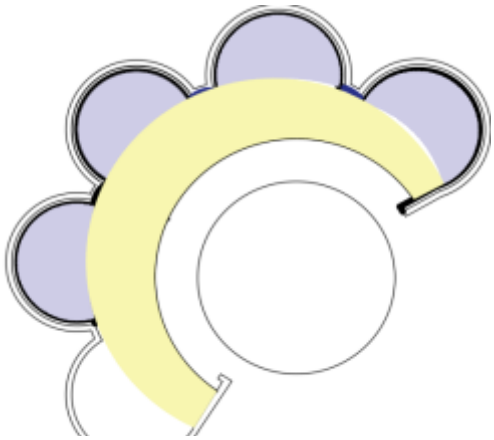


Figure 18(source;author)

- Room Area = 150 sqft
- Circulation area for single gallery = 120 sqft
- Height of the Exhibition galleries = 15’
- Corridor width =9’-8”

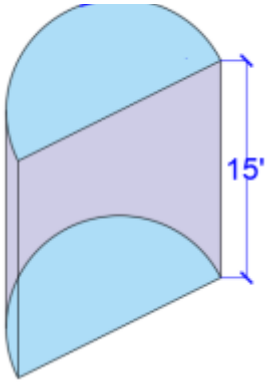


Figure 21(source;author)

Figure 20(source;author)

Figure 22(source;author)

3.1.4.3 Entrance (Boat Building)

It is a 360-degree mural depicting the past and the present of Punjab, as seen in its villages and towns and cities.
When you enter this gallery, it is pitch dark, suddenly broken by the sound of birds chirping and a blue tint of light. The room is like a deep well with adorned walls beginning with the dawn of the day, taking you through numerous memories.

INFERENCES

The Virasat-e-Khalsa museum is divided into multiple exhibition galleries which are mainly designed to narrate the history and culture of Sikhism through advanced technological methods. The galleries emphasize creating immersive visitor experiences.

The use of different type of digital technologies and traditional artistic methods has been integrated to create engaging narratives

3.1.4.4 Display for Audio-Visual Integration:

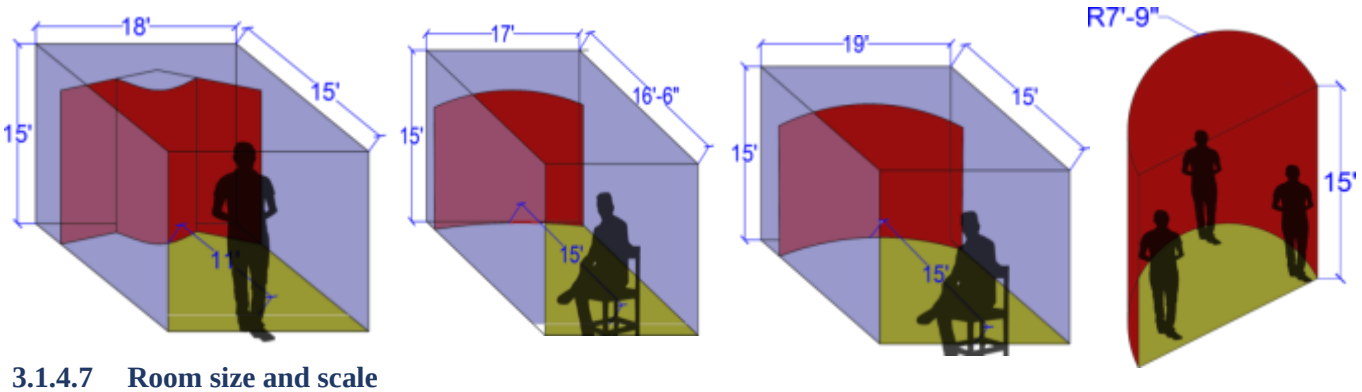
- Large-scale 3D projected screen are synchronized with soundscapes.
- Wide-format visuals, 180-degree panoramic screens, and dynamic lighting systems that reflects the historical environments.

3.1.4.5 Augmented Reality (AR) display:

- At the entrance of the museum visitors can scan QR codes using smartphones or tablets to access additional interactive content related to Sikh history and culture. They can also get access to their build in application for the museum.

3.1.4.6 Multimedia Galleries:

- These include story walls blending digital displays with traditional techniques like hand-painted murals to depict teachings of Sikh Gurus.
- Use of technology recreates the real-life environments through 360 degree screen and for visualization.



3.1.4.7 Room size and scale

- In this particular case study the room sizes and space parameters varies from 270-300 sqft .
- This particular room scale comfortably support 16:9 displays for 180-degree projections.
- In both the cases either standing and siting the viewing distance is 11’ and 15’.

- According to the previously discussed thumb rule of display areas for 3D projected screen **theViewing distance is 1.5 time the height of screen**, the screen height is approximately 10' i.e**the viewing distance would be 15', which is ideal as per thumb rule.**

3.2 PRADHANMANTRI SANGRALAYA

3.2.1 INTRODUCTION

The Pradhanmantri Sangrahalaya a museum dedicated to the Prime Ministers of India, goes beyond artifacts and historical narratives. It stands as a testament to the hands that have shaped the nation, representing India's rise as a global power. At its core, the museum presents a profound concept – India's leaders moulding a rising form, much like a potter's wheel, symbolising the collective efforts of the Indian people and its visionary leaders in shaping the nation. The museum pays tribute to an emerging and ever-evolving India, guided by its statesmen over the years. The Pradhanmantri Sangrahalaya artfully combines architectural elements, structural innovation, and landscape design offering a captivating experience to visitors.

Inspired by the Ashoka Chakra on the Indian Flag and its 24 spokes the museum embodies the spirit of comprehensive development and continuous progress. The building itself is a powerful and modern statement, capturing the imagination with its distinctive form and enchanting presence. Every aspect of the museum has been meticulously crafted to enhance the visitor's experience and create an atmosphere that inspires awe introspection.

3.2.2 Technologies Integrated

- AR-enabled Timeline Walls:
  In the orientation area and along the exhibits, visitors can use museum-provided tablets or their smartphones to scan portions of the timeline. The AR overlays activate, showing additional images, video clips, and infographics related to each Prime Minister's tenure.

- VR for Historical Event Simulations:
  VR headsets offer fully immersive simulations of pivotal historical events, such as parliamentary sessions, and iconic speeches.

- VR Tours of Prime Ministerial Journeys:
  Some VR experiences are designed to give viewers a glimpse of the international travels and diplomatic missions undertaken by India's Prime Ministers. For instance, visitors can virtually experience Vajpayee's interactions with foreign leaders or Indira Gandhi's appearances on the global stage, which influenced India's foreign policy. (Bharti, n.d.)

- Holographic Speeches by Prime Ministers:
  Life-sized holographic displays recreate historic speeches by different Prime Ministers, allowing visitors to experience these powerful moments as though they were occurring live. This technology captures the facial expressions, gestures, and vocal tone of each leader, adding emotional depth to the viewing experience.

- Interactive Q&A with Holograms:
  Some holograms may even be interactive, allowing visitors to choose from a set of pre-determined questions and receive answers based on actual quotes and documented responses from the Prime Ministers.

- Educational Games in AR:

This area uses AR games to teach children about India's Prime Ministers and significant events in a fun and engaging way. Interactive puzzles, coloring activities, and storytelling apps introduce young visitors to important historical themes in a simplified format.

(BUILDING 1)
GROUND FLOOR PLAN

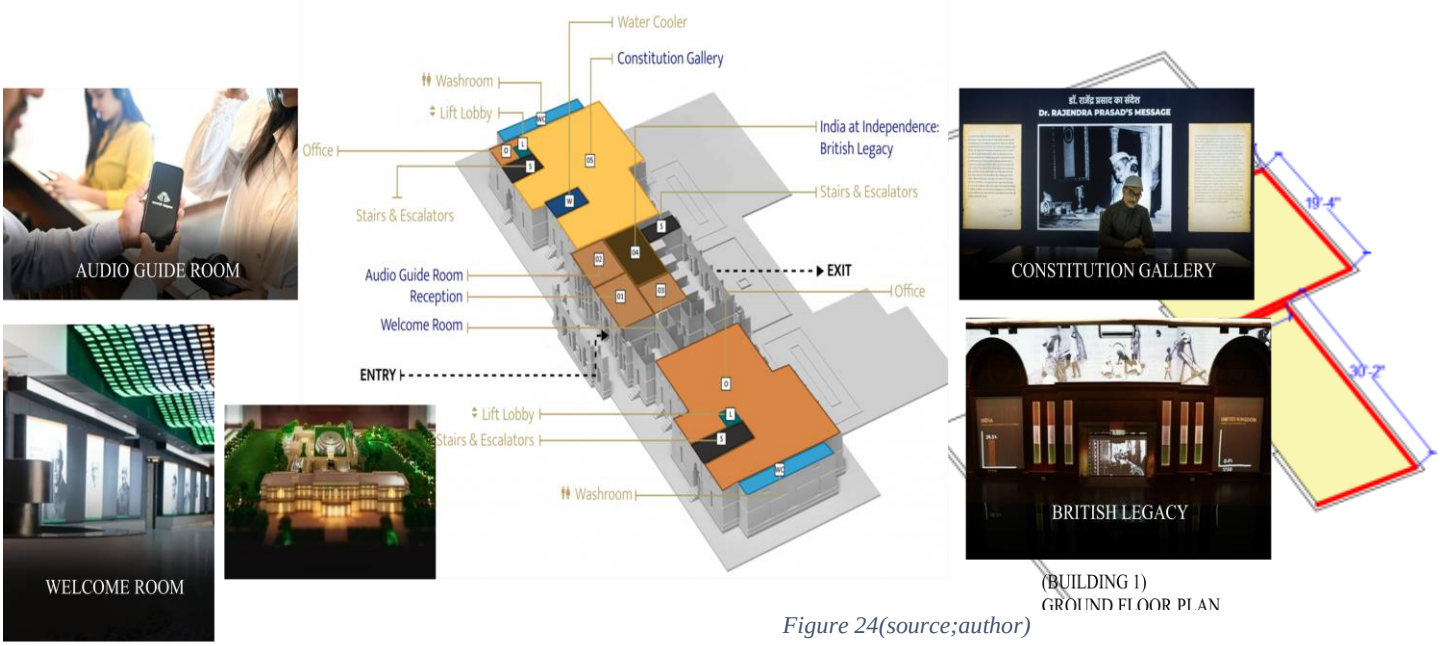


Figure 24(source;author)

Figure 23(source:bharti,n.d)

DISPLAY AREA- –

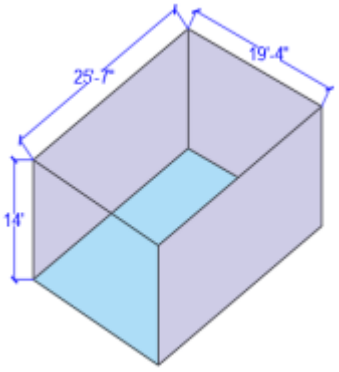
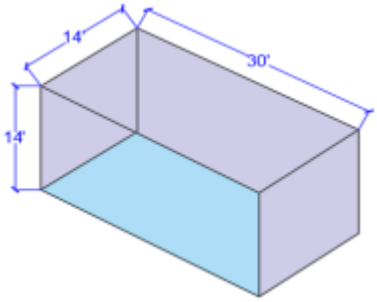


Figure 26(source;author)

420 – gallery



- Room area = 490 sqft
- Height of the = 14'

Figure 25(source;author)

BUILDING 1
SECOND FLOOR PLAN

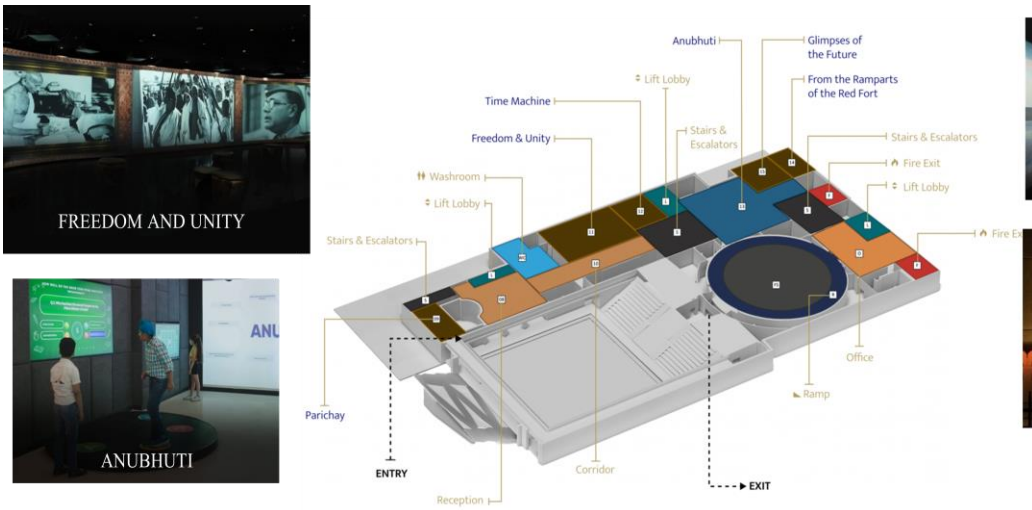


Figure 27(source:bharti.n.d)

- Room area for bigger display = 790 sqft
- Room area for small display = 250 -360 sqft
- Height of the gallery = 14’

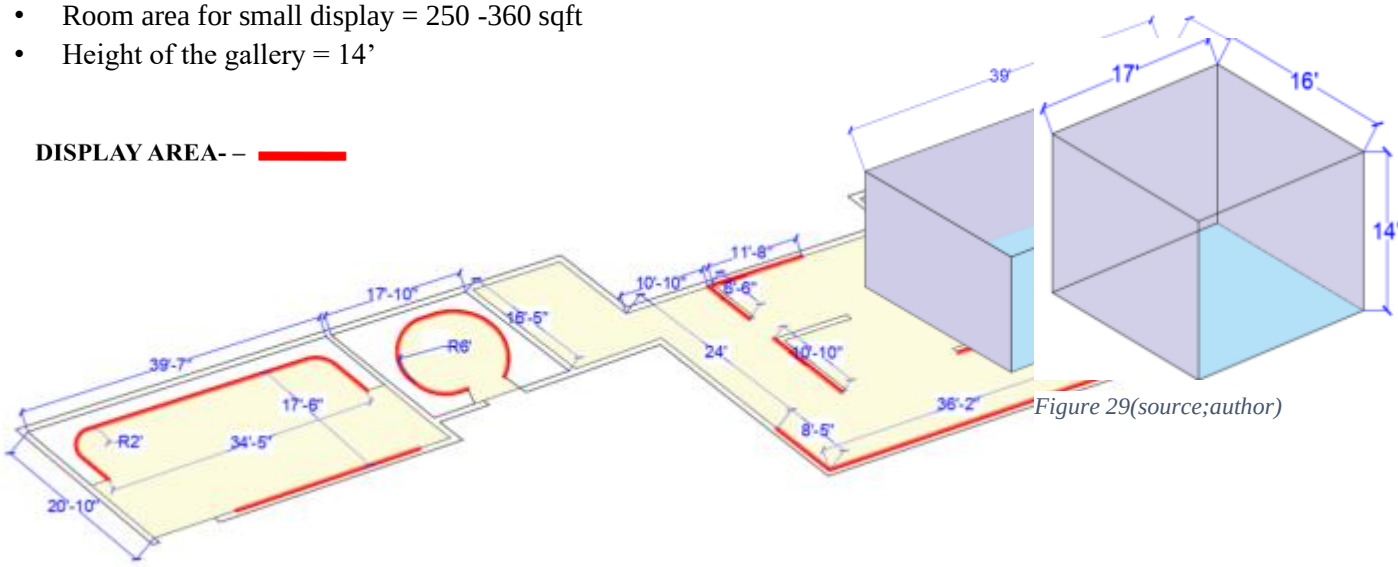


Figure 29(source;author)

Figure 28(source;author)

Figure 30(source;author)

3.2.3 INFERENCES

3.2.3.1 Technologies integrated

- AR Timelines:

  Wall-mounted AR display along the pathways and wall enable users to interect without obstruction with enough circulation area i.e 250 sqft.

- Interactive Zones:

  Interactive display with semicircular seating arrangements around displays, ensuring equal visibility and comfortable interaction.

  Larger spaces for multi-user interactive holographics or AR-enhanced setups.

  The room is specifically dedicated for VR setups (e.g., historical event simulations or PM journeys) which is around 420–450 sq. ft. for experiencing prime ministers journey without overcrowding.

3.2.3.2 Room size and scale

- In this particular museum the life-sized holograms or larger 3D screens are placed at a minimum distance of 6–8 ft from the nearest viewer.
- To offer the better visibility to large group of people the screens are slightly tilted to 15°.
- Centering the screen at eye level (~5.5 ft) for a standing audience maximizes engagement

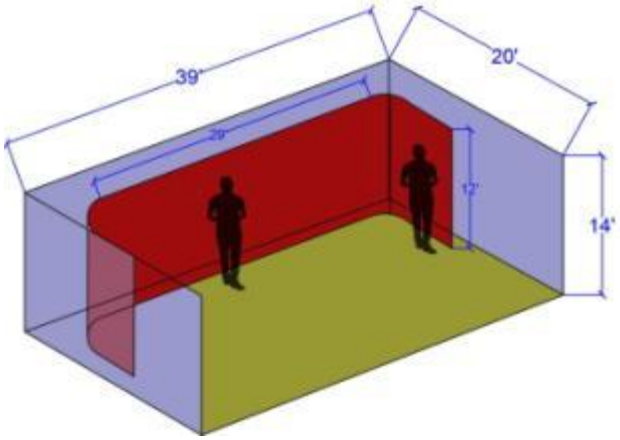


Figure 31(source:author)

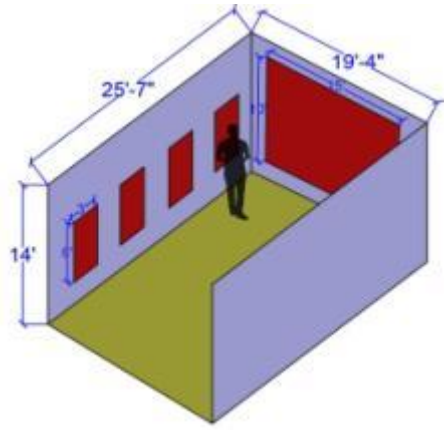


Figure 32(source:author)

3.3 THE TATE MODERN , LONDON (MODERN AND CONTEMPORARY MUSEUM)

3.3.1 INTRODUCTION

Tate Modern is a renowned art museum located in London, dedicated to modern and contemporary art. It is part of the Tate network, which includes several other significant art institutions in the UK. Opened in 2000, Tate Modern is housed in the former Bankside Power Station, a striking industrial building that has been transformed into a dynamic cultural space. (Modigliani VR: The Ochre Atelier, 2017)
Tate Modern holds an extensive collection of international modern and contemporary art, with works from the 20th century to the present day. The collection includes paintings, sculptures, installations, photographs, and multimedia works from major artists like Pablo Picasso, Andy Warhol, Mark Rothko and Amedeo Modiglian. (Tate, n.d.)

3.3.2 Modigliani VR: The Ochre Atelier

- This VR experiencial space that has been created as part of a special exhibition at Tate Modern focusing on Modigliani. It allows visitors to virtually enter Modigliani's studio, interact with the space, and gain deeper insights into his artistic process.
- The VR experience was created to celebrate Modigliani's legacy by allowing users to explore his studio as it was during his lifetime in early 20th-century Paris. (Tate, n.d.)
- The main aims was to provide a multi-sensory understanding of his artistic environment and the influences that shaped his work.

3.3.3 What is the VR about?

The Ochre Atelier reimagines Modigliani's final Parisian studio, where he lived and worked in the final months of his life in 1919 and 1920. Using archival research, the studio was meticulously reconstructed to include over 60 objects that were present in Modigliani's actual workspace. This includes furniture, easels, and other artistic tools, reflecting the creative atmosphere that surrounded the artist during his prolific period. (Tate, n.d.)

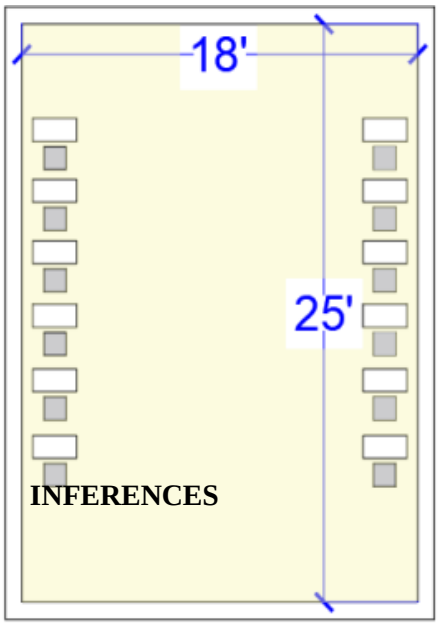


Figure 34(source:author)

- Room area = 450 sqft
- Height of the gallery = 12'
- No. of user at a time = 12

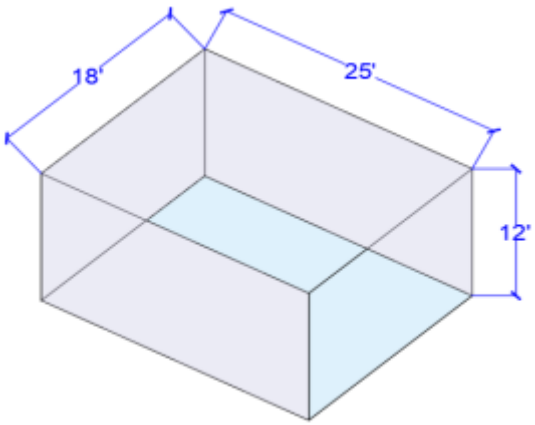


Figure 33(source:author)

3.4 INFERENCES

3.4.1 Technologies Integration

- The room was tailored for seated VR experiences with built in sensors, with no need for movement so the room scale doesn't hinders the experience.

- The type of headset used for VR experience is HTC Vive headsets with precise tracking and integrated audios, sensors and trackers.

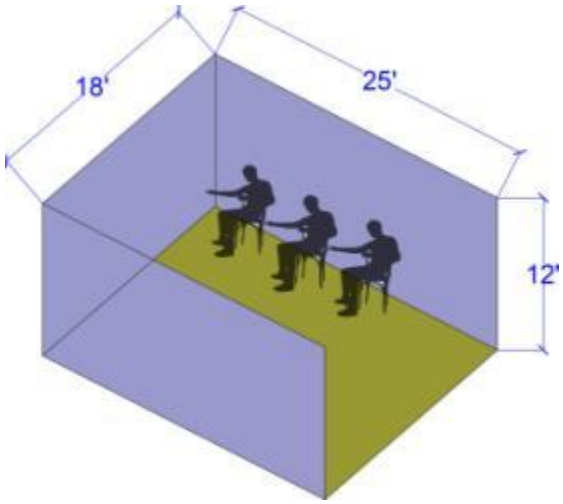


Figure 35(sourceauthor)

3.4.2 User Flow and Capacity

- This space is designed for 12 users at a time, balancing experiences with optimal space utilization and zero moement.

3.5 GRANDE GALERIE DE L'ÉVOLUTION, PARIS MUSEUM OF NATURAL HISTORY (AREA- 6000sqm)

The magic of the place created by Jules André in 1889 remains intact: an immense "nave", surrounded by three balconies, lit by a 1,000 m² glass roof, bears witness to the metal architecture of the time.
Cast iron and glass mixed with woodwork are combined with modern equipment: LEDs, screens, to better enhance the restored collections. The monumental staircases are now accessible and hold many surprises: models, statues, busts and even tombs.

3.5.1 TECHNOLOGIES INTEGRATED

- The museum uses high-resolution VR headsets and AR-compatible tablets. These devices are equipped with custom software that combines 3D models, soundscapes, and animations (Rivard & Scott, 2022).

- Content development involves collaboration with biologists and animators, ensuring accuracy in depictions of extinct species and marine life (Thomas & Wade, 2023).

- The museum offers a VR headset experience that immerses visitors in a simulated underwater journey, allowing them to explore coral reefs, interact with various fish species, and witness the impacts of climate change on ocean habitats (Thomas & Wade, 2023).

Figure 36(source: velys and ryans,n.n)

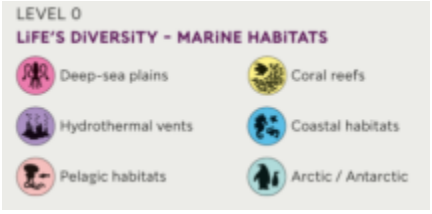
- Some floors are designed as when viewed through AR-enabled devices, these extinct species are animated to show behaviors and sounds, giving the impression that the animals are "alive" in the space.

3.5.2 LAYOUT

- On the ground floor, three marine mammal skeletons welcome you: the southern right whale, the blue whale and the sperm whale are gigantic.

- On the first level, the elephant leads the caravan of animals from the African savannah. The large mammals and their predators follow suit. Buffalo, hartebeest, wildebeest, giraffe and zebra, hyenas, wild dogs, lions and cheetahs: guess who eats whom.

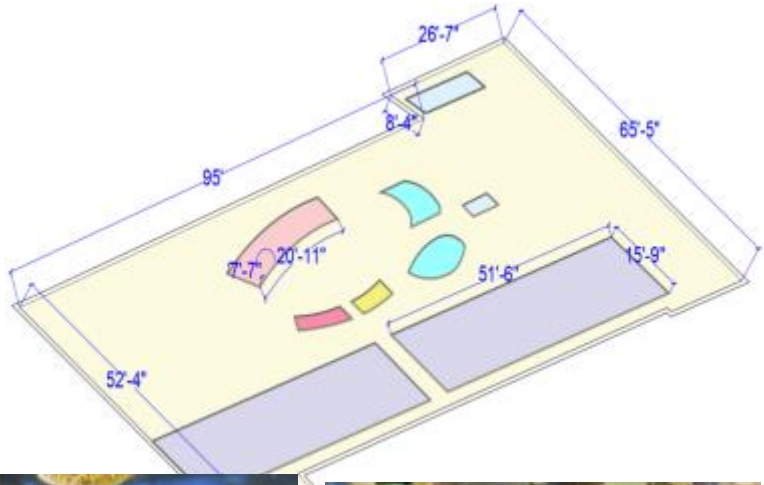
- Second floor covers the Mankind's hold on nature nad is punctuated by technical developments that modify ways of eating or traveling: hunting and gathering, fishing, domestication of animals, modification of landscapes, pollution, etc (Muséum National d'Histoire Naturelle, 2022).
- Third floor tells us about the history of living organisms and the adventure of the naturalists who have deciphered it. This is the time to look into the secrets revealed by the observation and study of anatomy, fossils and molecules.

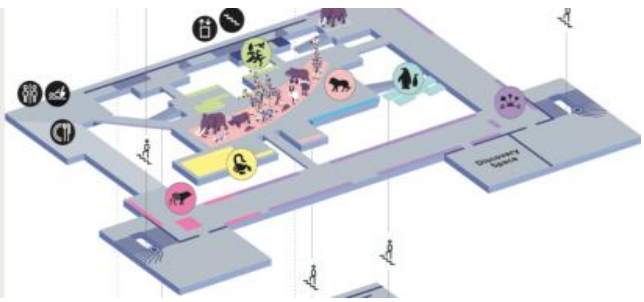


Floor area for exhibition display = 7500 sqft

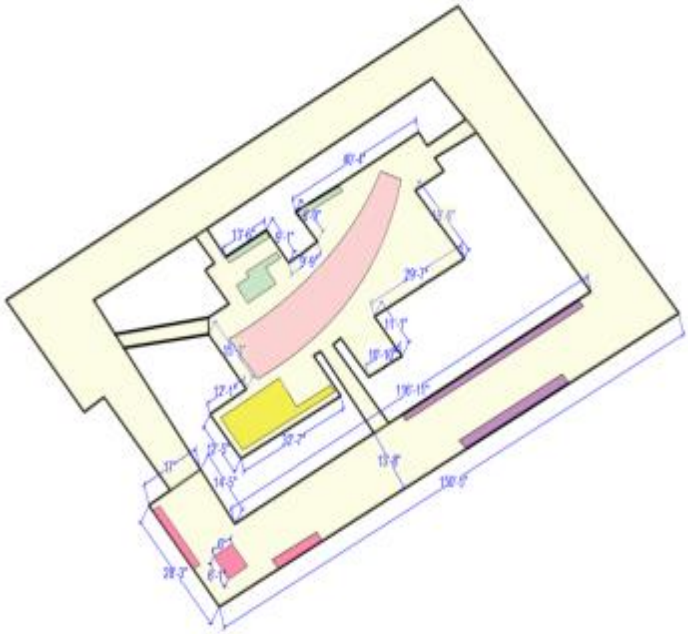
Circulation area = 3800 sqft

Height of the gallery = 15'

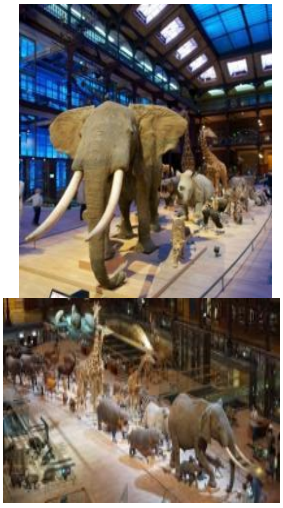


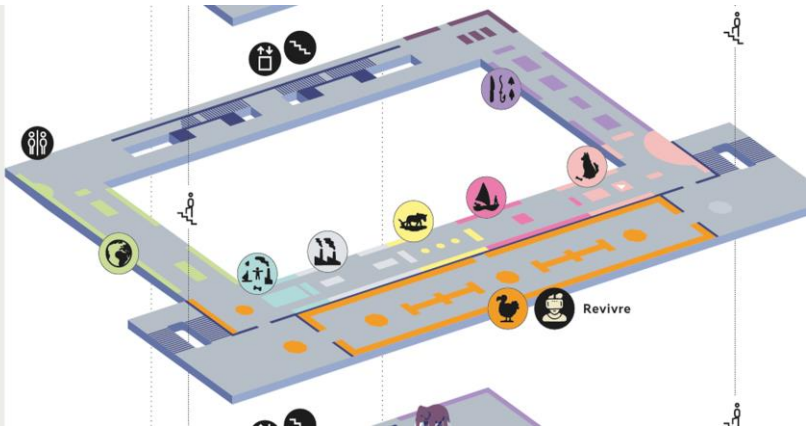


Area for centre display area = 2300 sqft
Circulation area for centredisplay = 1600 sqft
Area of corner display area = 1900sqft
Circulation area = 1650 sqft



Height – Triple heighted





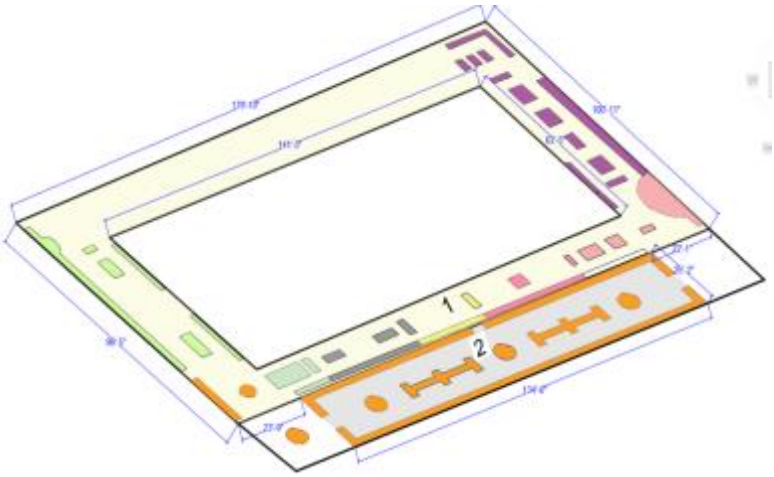
Area for display 1 = 5000 sqft

Circulation area for display 1 = 3800 sqft

Area of display 2= 2700sqft

Circulation area for display 2 = 1790 sqft

Height of the gallery = 15’



3.5.3 INFERENCES

3.5.3.1 Technologies intergated

VR and AR Setup

- Users can swipe or pinch on a screen of touchscreen display to interact with a 3D dinosaur skeleton or zoom in on a prehistoric scene.
- Walking alongside animated mammoths by wearing VR headsets visitors can immerse themselves in animated models or related scenes.
- AR-compatible tablets are placed near the display screens of animated models so that user can interact with them easily .
- Some exhibits feature the **motion sensors** that allow visitors to interact with models through gestures as waving hands to trigger animated models.

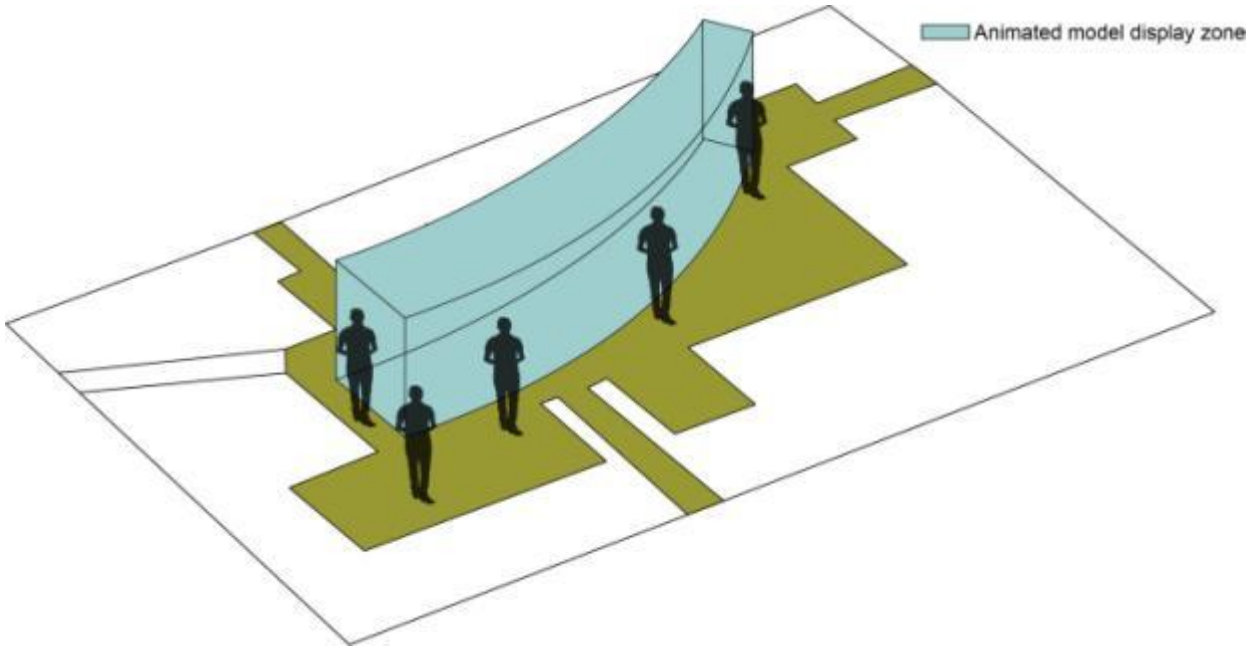


Figure 37(source:author)

3.5.3.2 Flow and Navigation

Clearly defined circulation areas (50% of display space) ensure smooth movement even during peak times.Centralized displays with ample surrounding circulation areas provide focal points without overcrowding.

4 CHAPTER -4 RESULTS AND FINDINGS

4.1 FOR 3D INTERACTIVE SCREEN

Minimum room area required = 144 sqft (For instance 12'*12'), approx. 13.4 sqm
Thumb rule for distance = screen height * 1.5

- For Screen size – 10' * 5'8"
  Viewing distance – 9'
- For screen size – 15' * 8'9"
  Viewing distance – 13'

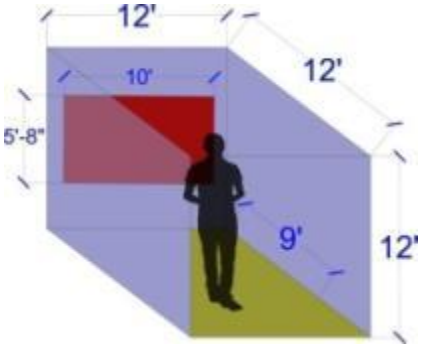


Figure 38(source:author)

4.2 FOR VR SCREENING

Minimum room area required = 144 sqft (For instance 12'*12'), approx. 13.4 sqm
Thumb rule for distance = screen width * 0.56

- For Screen size – 10' * 5'8"
  Viewing distance – 5' - 6'
- For screen size – 15' * 8'9"
  Viewing distance – 8' - 9'

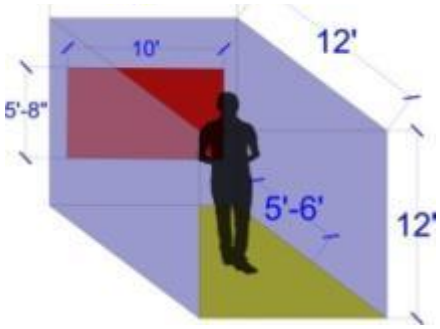


Figure 39(source:author)

4.3 FOR VR SETUP WITHOUT SCREENING

For VR setup without screening , we need the enclosed space of any dimension with seating arrangement. The headset required for the same is HTC VIVE with inbuild motion sensors and tracking.

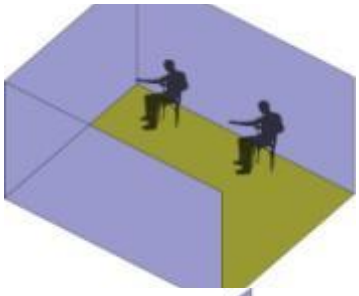


Figure 40(source:author)

4.4 FOR AR DISPLAY SCREEN

For AR display screen we need a display which is accessible at human eye level i.e 5'5"

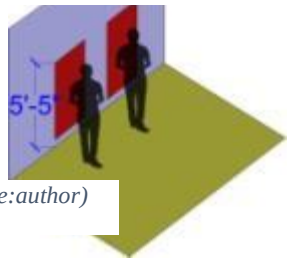


Figure 41(source:author)

4.5 FOR AR AND VR HIGH END MODEL DISPALYS

- For this setup we need the display zone secured with glass with models having inbuilt sensors and tracking.
- For interaction with models one should have smartphones and tablets attached with VR headset to fully experience the environment.
- Beside display zone their should be enough space for circulation alongside the display for interaction with models.

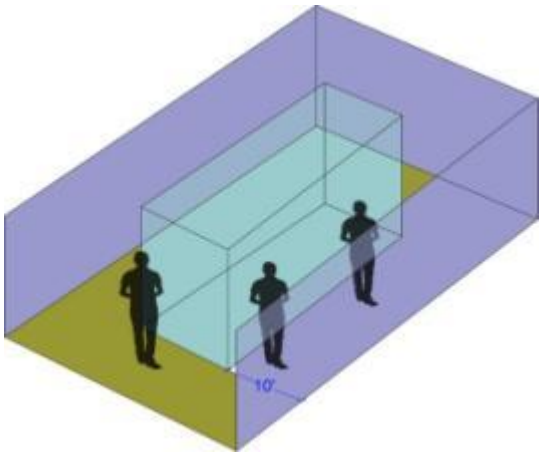


Figure 42(source:author)

CHAPTER 5 – CONCLUSION

This research demonstrates the transformative role of Information and Communication technologies in enhancing museum experiences. By addressing spatial requirements, equipment needs, and interactive display setups, the study provides a practical framework for their effective implementation. The study delves into critical aspects such as **spatial requirements, viewing considerations, and equipment specifications,** providing a comprehensive framework for implementing these technologies effectively.

The findings demonstrate that appropriate planning—ranging from the minimum room area of 144 square feet for VR setups to the importance of accessible display heights for AR screens—plays a pivotal role in ensuring a seamless and engaging visitor experience.

Beyond technical aspects, Information and Communication technologies enhance educational outreach, storytelling, and accessibility, attracting diverse audiences while preserving cultural heritage. This study serves as a guiding framework for institutions aspiring to adopt these technologies and lays the groundwork for future research into optimizing these experiences further, ensuring they remain impactful and sustainable in the years to come.

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