

Research Article

AI Implementation in Art Museums Through Sensory Design

Ayisha Saniya Ambalavan^{1*} and Ashwarya Chauhan²¹Manipal Academy of Higher Education, India²Indus University, India**ORCID:**Ayisha Saniya Ambalavan: <https://orcid.org/0009-0001-0298-5355>Ashwarya Chauhan: <https://orcid.org/0000-0001-9758-4994>**Abstract.**

This research paper compared the use of advanced technology like AI in modern art museums with the traditional art museums. It focused on the display of art forms that help create a more immersive experience for visitors by engaging the five senses with the help of sensory factors such as sound effects, visual stimuli, haptic design, and tactile forms. In the digital age, it is essential to enhance spaces using growing AI technology to accommodate emerging art forms. In India where culture is rich and timeless, it is imperative we welcome new changes to the perceptions of art. A comparative analytic table has been prepared by using associated keywords to find research papers from various sources (Google Scholar, Springer, Research Gate). Furthermore, national and international case studies were explored, and a thorough analysis of the space and usage of AI technology was conducted. After collecting the secondary data, the primary data was collected using the interview method through digital forms. The collected information through both online and offline methods underwent a comparative analysis, from which a conclusion was derived. As such, this paper proposes how art museums can be further developed and designed using AI technology and multi-sensory features to increase visitor engagement and understanding, by creating a space that can accommodate all art forms in the Indian context. It thereby discourages prejudices against introducing AI into artistic and cultural spaces.

Keywords: visitor experience, AI technology, interactive spaces, art museum, sensory factors

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1. Introduction

This paper aims to investigate and propose prospects on how art museums are required to be redesigned using digital technology such as AI through sensory design.

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2. Objectives

1. To analyze visitors' experience in art museums.
2. To discover recent technological advances such as AI targeting sensory design.
3. To explore Factors such as sound effects, visual stimuli, haptic design, and HCI.
4. To understand the emerging art forms and their requirements.

Scope-- To study the current technological advances including but not limited to AI, and conduct surveys to understand visitors' experience, to observe current art museums using similar designs, and to understand the forms of sensory design.

2.1. Limitations

- This study focuses on only Exploring Sensory design in art museums.
- This study is limited to only Using Technology as a medium.

Methodology-- Qualitative methodology

Relevance/Significance-- The significance of this study is to understand the visitor's experience in Art museums, to analyze the emerging art forms and the spaces they require, and to redefine the art museum with the help of digital technology through sensory forms.

Research Questions--

- RQ1: How does the rapid transformation of art require a change in the space displaying it?
- RQ2: How can AI contribute to visitor enhancement in Art museums?

Background study:

Table 1 displays the findings of the background study.

Research Gap

In Figure ??, to the right, we can understand how each sense can merge into another using technological tools and systems. The boxes in red showcase the multi-sensory solutions that are already in use, whereas the boxes in blue show solutions that are available but not used in art museums, and are more than the red boxes, the rest of the table in white are open to research and discovery [?].

"Lack of research on using technology to amplify sensory design in art museums."

TABLE 1: Comparative Analytic table.

S.no	Article	Author	Objectives	Findings	Interface
01	Museum experience design is based on a multi-sensory Transformation approach. [?]	Author: Harada, Tazuru; Hideyoshi, Yanagisawa; Gressier-Soudan, Eric; Jean, Camille- year: 2018	Objectives 1	- Study museum visitors' experience. - In-depth study on multi-sensory design. - Comparison of both - MVE & MS.	- exploring multi-sensory design approaches through various techniques. - Examining museum visitors' experience.
02	Questions and Answers: Important steps to let AI Chatbots answer Questions in the Museums. [?]	Schaffer, S., Ruß, A., Sasse, M.L., Schubotz, L., Gustke, O. (2022)	Objectives 2 and 3	-Using an AI-based prototype called CHIM to allow interactions using text and speech.	-Conducted tests in Stadel Museum- displaying the use of this prototype to enhance visitor engagement.
03	Application of AI Interactive Device Based on Database Management System in Multidimensional Design of Museum Exhibition Content [?]	Pei gyu Cai, Kuan Zhang, Young Hwan Pan, 2023	Objectives 2 and 1	- The introduction of AI interactive devices based on a database management system in museums led to a significant increase in visitor satisfaction.	- Multi-dimensional exhibition content received a high satisfaction score of 8.92. Voice guidance achieved a 91.98% satisfaction rate.
04	Interactive Technologies in Museums: How Digital Installations and Media Are Enhancing the Visitors' Experience [?]	Fernandes Vaz, Odete Fernandes, and Rocha Veiga- year: 2018	Objectives 1 & 2	- Talks about the benefits of digital media in exhibitions and museums, that increase interaction.	- What various digital installations, and technology like - QR codes, Social media, and AR help increase interactions?
05	Towards multi-sensory design: Placemaking through immersive environments – Evaluation of the approach [?]	Anastasia Globa, Beau B. Beza, Rui Wang, -year 2022	Objectives 1 & 2	- Traditional methods of communication have disadvantages over multisensory systems.	- To explore incorporating olfactory senses in the VR approach to create immersive spaces.

Source: Multiple Papers provided in the reference.



Figure 1: Museum experience design based on a multi-sensory transformation approach.

3. Literature Review

From these two Tables 2 and 3 shown below, we get a statistic on art museums and their visitors.

TABLE 2: Museum Types and Visitor Percentages in India.

Museum Types	School children	College Students	Society mass
History and folklore	31.29%	13.26%	21.24%
Art	27.43%	33.21%	32.83%
Military	22.74%	35.58%	27.32%
Celebrity homes and memorials	18.54%	17.95%	18.16%

TABLE 3: Museum Types and Visitor Percentages in India.

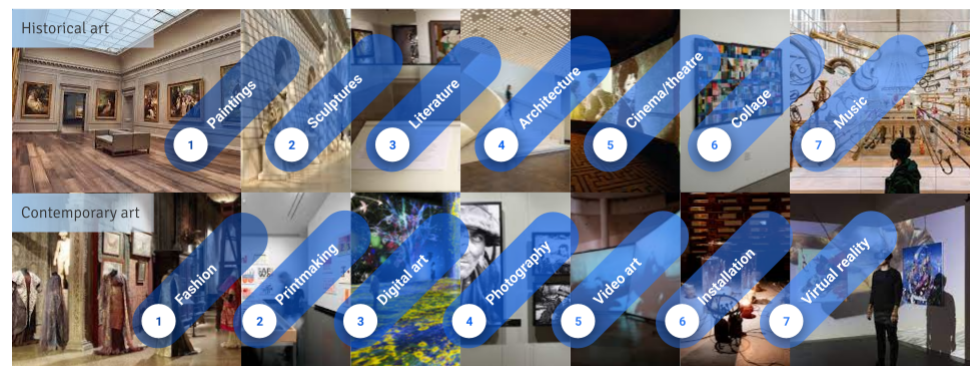
Time	2015	2016	2017	2018	2019	2020
Number of art galleries	57423	65432	59678	59082	57340	59236
Number of Exhibitions	102341	130987	120354	11789	12302	12804

3.1. Purpose of Art Museums

It was discovered that visitors to the modern art museum approached their visit with an approach that was mostly emotionally affecting and pleasure-seeking, whereas visitors to the Historical art museum approached their visit with an approach that was primarily knowledge- and understanding-seeking [?]. Educational attainment has an impact on the number of happiness visitors have and what kind of aesthetic experience people receive. Visitors to the Ancient art museums were motivated by a desire to comprehend and learn, whereas those to the modern art museums were more motivated by emotion [?].

- Types of art forms:

There are various types of art forms displayed in museums, and art is a term that is evolving and expanding, here are the main types of art found displayed in museums.



Transforming art museums using digital technology through sensory design to increase consumption of art: A new perspective

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Figure 2: Types of art forms. **Image source-** All images are from Google.

3.2. New Emerging Art Forms

One of the emerging mediums is VR art, which offers an immersive medium like no other. (see Figure ??). Studies show that VR provides ideological developments [?]. The display created by Australian company Grande Experiences is not the first to reinterpret van Gogh's artwork for the digital era (Figure ??). An exhibition at the Indianapolis Museum of Art in Newfield's The permanent piece, titled "The Lume," will reflect over 3,000 pictures of the Dutch painter's artworks onto the walls, ceilings, and floors of the museum's fourth-floor galleries using 150 digital projectors. The show, which covers 30,000 square feet, is the biggest in the 137-year history of the Indiana

Museum. classical music will be played to enhance the realistic experience. It also offers food to enhance the olfactory senses.

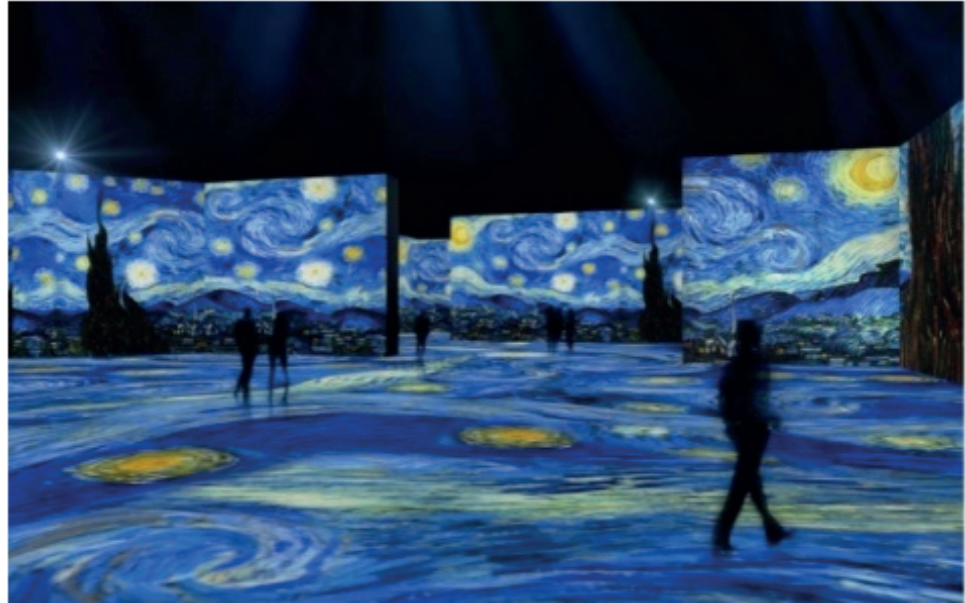


Figure 3: 360 Van Gogh exhibition. Source: Davis-Marks I. Step Into “The Starry Night” and Other Vincent van Gogh Masterpieces [Internet]. Smithsonian Magazine. 2020. Available from: <https://www.smithsonianmag.com/smart-news/new-van-gogh-exhibition-lets-viewers-sit-under-starry-night-180976190/>.

3.3. Sensory Design

- Intro – There are primarily 5 senses known to us: touch, sight, smell, taste, and hearing. As a designer, we must create spaces that can be experienced in a multitude of ways. Sensory design is inclusive, it supports the heterogeneity of humans. A multi-sensory experience requires two or more senses to be used (see Figures 4 and 5). It is a vital aspect of the future of art museums. It brings the interconnection between the spaces and the human being. Tactile support- is a form of touch that helps mobilize people with loss of vision. [?]
- Haptic design - It is a form of design that deals with user experiences in forming a tether between interactive technology and multi-sensory design (see Figure ??).

3.4. AI Technological advances

HCI- human-computer interaction, is where researchers and designers can harness the senses in experience design. They use touch, smell, and hearing in collective

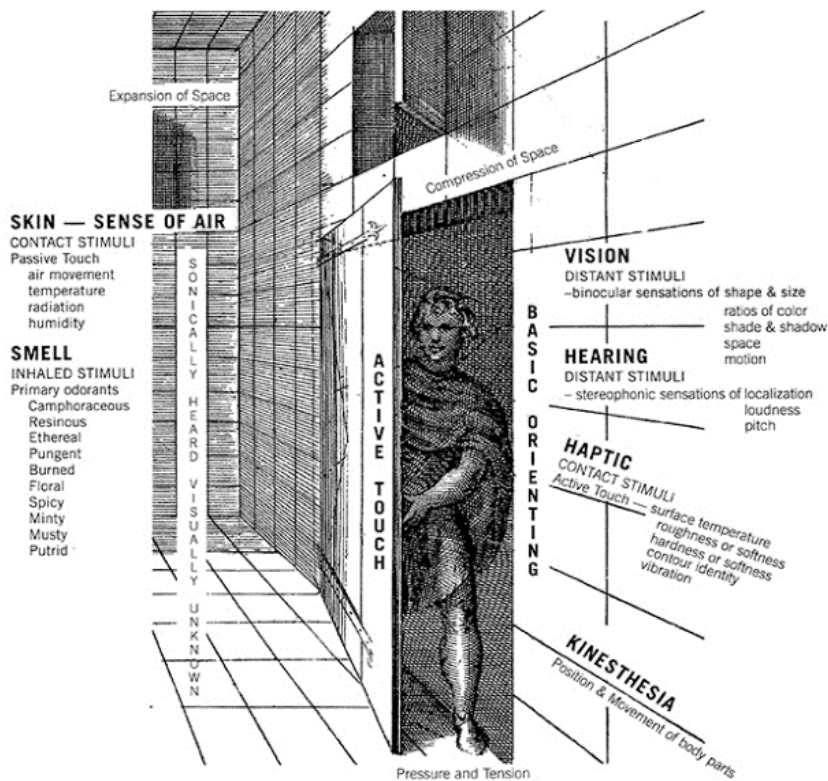


Figure 4: Different Range of senses and their types. Source: Malnar JM, Vodvarka F. Ranges of the senses. In [eds]. Sensory design. University of Minnesota Press; 2004. p. 151.

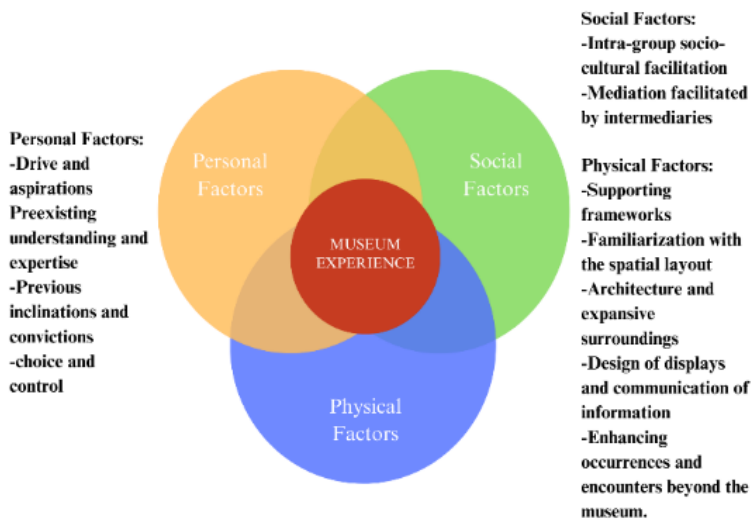


Figure 5: The Museum Experience Model. Source: Falk JH, Dierking LD. The museum experience revisited. Routledge; 2016. DOI: 10.4324/9781315417851.

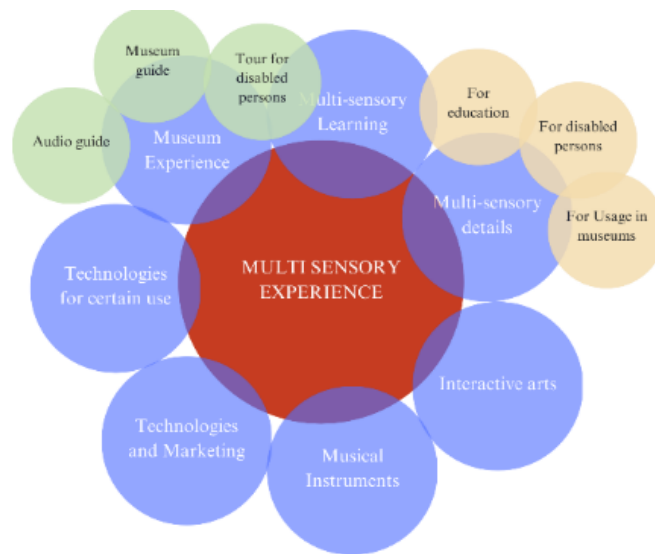


Figure 6: Multi-sensory experience Diagram Image source: museum experience design based on multi-sensory transformation approach.

engagements. The interaction paradigms that can be adopted in a museum exhibition involve hybrid interactive artifacts, i.e., installations that support visitors manipulating and interacting with physical and digital exhibits [9,10].

This was conducted at Harvard’s Art Museum where machine learning took place to study the choreographic movements of human beings and create art exhibitions through a machine called a surprise machine which is a data visualization that charts over 200,000 digital images spatially and allows visitors to interact with AI through a camera with the digital exhibition showcasing the collection at HAM [?] (Figure ??).

3.5. Hypotheses

“Sensory Design techniques using advanced Technology such as AI in Art Museums will increase visitors’ Experience and Consumption of Art.”

Tables 5, 6, and 7 display the results of analysing case studies related to this hypothesis.

3.6. Comparative Analysis of Case Studies

Other Specific examples of cutting-edge technology include.

Henry Ford’s Connections Table is a captivating fusion of curator-led concepts and AI-driven discoveries (Figure ??). This innovative touchtable invites visitors to delve



Figure 7: Surprise Machines test at the Harvard Art Museum’s Lightbox Gallery showing the choreographic interface in action.

TABLE 4: Major Primary case studies (Bangalore, India).

Name	Indian Music Experience Museum	National Gallery Museum of Arts
Project Details	Spread across 50000 sq. ft, 3 floors, and 9 exhibit galleries. IME is India’s first Interactive music museum.	Spanning across 3.5 acres, with Lush green gardens and shady trees. It was established in 2009, in the Manikyavelu mansion.
Salient Features	<ul style="list-style-type: none"> • Immersive spaces to divulge. • Self-exploratory easy to understand. • Touch and explore-Interactive. • Games and fun activities. 	<ul style="list-style-type: none"> • Lots of open courtyards. • Exposed to nature in the pathways. • Timeless architecture. • Focused on visual displays.
Senses Impacted	Vision – hearing - touch	Vision
Interactive Technology	AV touchscreen-based games that regenerate music based on visitor interaction- Interactive screens.	As it is a Traditional Museum none are observed.

into an intricate network of interconnected objects, providing valuable insights into the pervasive spirit of innovation that defines the museum’s exhibits.

By employing a touchscreen interface, guests can sketch a facial expression and witness the subsequent analysis of emotions by a neural network. These AI procedures are presented in real-time through a holographic projection, providing visitors with a tangible comprehension of AI operations. Through enjoyable and interactive engagement with AI, visitors can cultivate a greater sense of comfort with

TABLE 5: Secondary vs. Primary case studies (India).

Name	National Museum Delhi	Museum of Goa
Project Details	One of the largest museums in India, established in 1949. Has over 200,000 works of art both foreign and local.	Spanning 1500 SQM – and founded by Subodh Kerkar in 2015. It showcases local artists as well as installations.
Salient Features	<ul style="list-style-type: none"> •Diverse art collection. • Touch and explore-Interactive. • Educational activities. 	<ul style="list-style-type: none"> • Lots of low-interactive exhibits. • Sense of smell is explored. • Modern artwork.
Senses Impacted	Vision – hearing - touch	Vision – touch - Smell
Interactive Technology	Holograms - Interactive video walls- 270 projection room - Transparent OLEDs – Projection - Interactive Touch table - Circular Projection mapping - Digital Photobooth.	Low interactive exhibits enhance senses, not much digital technology is involved, and there are few digital screens placed.

Source: National Museum, New Delhi [Internet]. nationalmuseumindia.gov.in. Available from: <https://nationalmuseumindia.gov.in/en>; Home - Museum of Goa [Internet]. Museum of Goa. 2024 [cited 2024 Aug 22]. Available from: <https://museumofgoa.com/>

TABLE 6: Secondary case studies (International).

Name	The Museum of Modern Art (MoMA), USA	The Van Gogh Museum, Amsterdam
Project Details	One of the largest and influential museums in the world, for modern art. Plays a major role in collecting and developing art.	Located in the Netherlands, it has a beautiful glass structure. Displays majorly the complete artwork of Van Gogh.
Salient Features	<ul style="list-style-type: none"> •Innovative Exhibitions on most trending topics every season. • Accessibility Initiatives. • Educational and research. 	<ul style="list-style-type: none"> • Chronological display of Van Gogh’s art. • Amazing modern architecture. • Educational programs.
Senses Impacted	Vision – hearing - touch	Vision – hearing
Interactive Technology	MoMA has experimented with AI-powered chatbots to provide visitors with information and guided tours. They also use AI for art cataloging and analysis. Along with a variety of digital exhibits.	interactive exhibits include- touch-screens and presentations. not much digital technology is involved especially AI. It is more traditional catering to his artwork other than the 360 exhibit.

Source: MoMA. MoMA [Internet]. MoMA. MoMA; 2024. Available from: <https://www.moma.org/>; Van Gogh Museum. Visit the museum about Vincent van Gogh in Amsterdam - The Netherlands - Van Gogh Museum [Internet]. Vangoghmuseum.nl. 2019. Available from: <https://www.vangoghmuseum.nl/en>

this technology and gain a deeper appreciation of its potential influence on our daily lives (see Figure ??).

Interview:

An Interview was conducted with the curators from both NGMA and IME, who were from the curatorial team and management team of the museums, it has been summarised below:



Figure 8: Henry Ford's Connection Table. Source: Bluecadet. LinkedIn [Internet]. Artificial intelligence (AI) and the modern museum [Post]; April 2023. Available from: <https://www.linkedin.com/pulse/artificial-intelligence-ai-modern-museum-bluecadet-interactive/>.



Figure 9: MIT Museum- Black Box Interactive exhibit. Source: Bluecadet. LinkedIn [Internet]. Artificial intelligence (AI) and the modern museum [Post]; April 2023. Available from: <https://www.linkedin.com/pulse/artificial-intelligence-ai-modern-museum-bluecadet-interactive/>.

3.7. NGMA (National Gallery of Modern Art)

Q1: Exhibition Name and Curation Approach

A1: The exhibition titled 'Reflection: Man, and Nature in the Paintings', is divided into Seekers, Majesty, Abode, and Rhythm. Curated with distinct themes for each part. The space is curated through installations, creating unique atmospheres. A dedicated room for the painter.

Q2: Interactivity Without Technology

A2: Used colours strategically, like yellow, complementing nature-themed paintings. Magnifying glasses are provided for small artworks. Focus on enhancing vision without flashy elements.

Q3: Visitor Demographics and Inclusivity

A3: Art enthusiasts, seniors on weekdays, families, youth, and architecture students on weekends. Inclusive features: wheelchairs, and lifts for accessibility.

3.8. IME (Indian Music Experience Museum)

Q1: Visitor Diversity and Outreach

A1: School groups, young adults, design students, families, marginalized communities, and neurodivergent kids. Outreach programs like 'Swarthy' for inclusive experiences.

Q2: Interaction Across Generations

A2: Children are more visually engaged, exploring exhibits. The older generation is nostalgic, explores interaction with digital displays, and takes time to absorb information.

Q3: NGMA Comparison and Interactive Design

A3: Appreciation for NGMA's serene atmosphere. We would suggest more interactive elements for inclusivity, recognizing diverse ways people engage with art.

Q4: Curatorial Approach and Design Considerations

A4: Focus on every detail - lights, sound, colour, and text. Curate information creatively, making it enjoyable and educational. Provide aids like headphones for accessibility.

3.9. Analysis

- 1. NGMA's Tranquil Approach:** NGMA values serene, quiet spaces for art appreciation. However, this might not engage all visitors, especially those needing interactive experiences.
- 2. Indian Music Experience's Inclusivity:** Emphasizes inclusivity through diverse programs and interactive exhibits catering to different ages and backgrounds.
- 3. Need for Inclusivity:** Both museums acknowledge the importance of inclusivity. Interactive designs can bridge gaps, making art and culture accessible to a wider audience.

This summary highlights the distinct approaches of NGMA and the Indian Music Experience Museum, emphasizing the importance of interactive and inclusive designs in engaging diverse visitors effectively.

Survey-Objectives

Understand Public Preferences Regarding Technology and Sensory Design in Art Museums. Questions Included Likert Scales and Multiple-Choice Items.

Visitor Demographics:



Figure 10:

Last Visit Frequency:

- 55% visited years ago.
- 29% visited months ago.
- Only 9.7% visited recently, indicating infrequent visits.

• Sensory Targeting:

- Visual Dominance: Most visitors' experiences focused primarily on visual aspects.
- Limited Interaction: Minimal emphasis on interaction in the museum space.

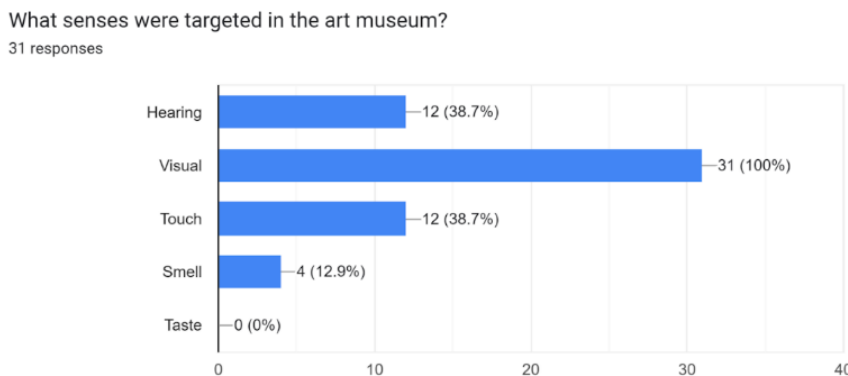


Figure 11:

Visitor Preferences:

- Preferred Interactivity

Rate your experience in the Art museum on Interaction?
31 responses

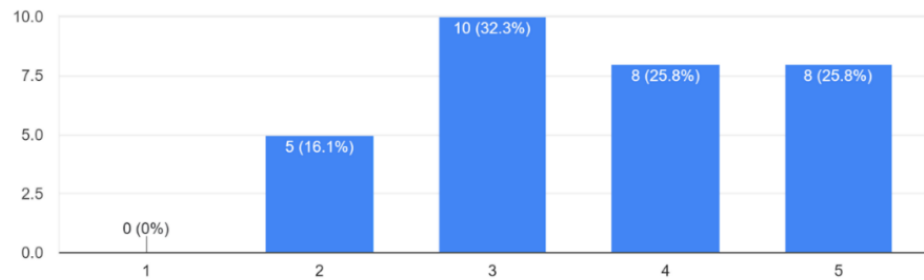


Figure 12:

- Digital Interactive Displays: The majority of visitors expressed interest in digital, interactive displays.
- Use of Van Gogh’s Art: Displayed in two different methods; digital displays were preferred for enhanced interaction and understanding.

What space would you require to display this art?
29 responses

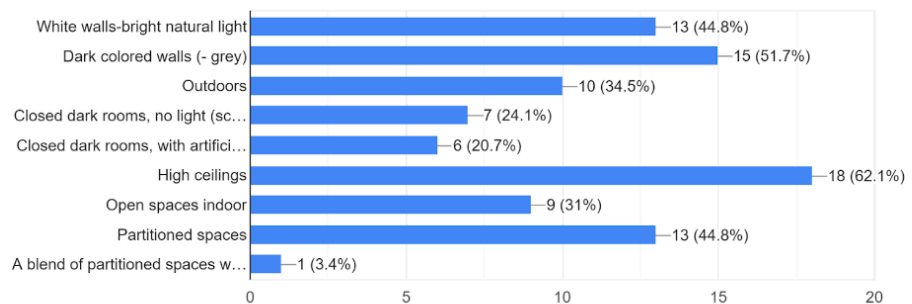


Figure 13:

Artist and Art Enthusiast Preferences

- Space Redesign:
 - Desire for Interaction: Artists and enthusiasts showed interest in redesigns promoting interactive experiences.
 - Digital Display Preference: Preferred digital methods for displaying artworks.

Last but not least, which of these Van Gogh displays in museums would you prefer to visit, and which would help you intake his art better?

31 responses

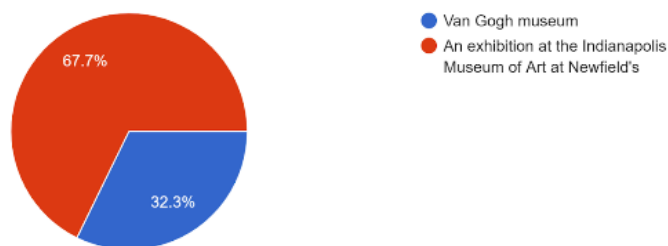


Figure 14:

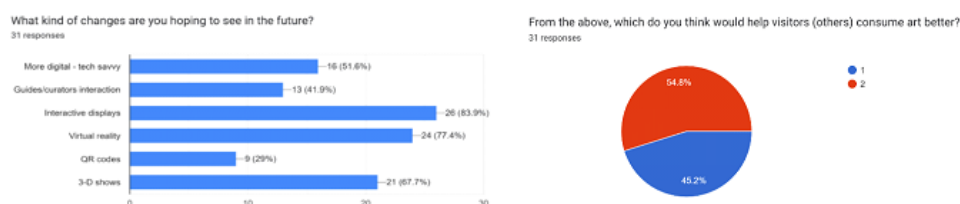


Figure 15:

3.10. Analysis

- **Infrequent Visits:** The data highlights a significant gap between museum visits, indicating a need for strategies to attract more frequent visitors.
- **Visuocentric Experience:** The focus on visual experiences might limit visitor engagement. Exploring other senses could enhance overall enjoyment and increase revisit rates.
- **Demand for Interaction:** There’s a clear demand for interactive displays, indicating a shift toward technology-driven engagement methods.
- **Digital Dominance:** The preference for digital displays, especially for renowned artworks like Van Gogh’s, suggests the potential of technology to enhance art understanding and appreciation.

3.11. Implications

- **Diversify Sensory Experience:** Introduce sensory elements beyond visual aspects to create a richer, more engaging museum experience.

- Invest in Digital Interactivity: Prioritize investment in digital, interactive displays to cater to the preferences of the majority and attract a wider audience.
- Promote Regular Engagement: Develop strategies to encourage more frequent museum visits, potentially through rotating exhibits, special events, or interactive installations to sustain visitor interest.

This survey data underscores the importance of embracing technology and diversifying sensory experiences to create a more engaging and inclusive art museum environment, ultimately encouraging repeat visits, and broadening the museum’s audience.

Note: All the above Pie charts and graphs were extracted from Google Forms.

4. Research Methods

Tables 8.1 and 8.2 summarize research methods.

TABLE 7: Methodology Part 1.

WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
Identification of topic:	Abstract and Background Study:	Aim, objective, scope, and limitations:	Introduction and data collection & methodology:	Research gap and Literature review:	Analysed Theoretical data, and formulated a hypothesis:
Explored areas of interest identified a topic and set limitations.	Developed an abstract based on the topic and conducted a background study.	As per the background study, re-developed the Aim, scope, and objectives	Data collected and reviewed more research papers, refined aim, and objectives.	As per data collected and a literature review, we finalized the research gap.	Analysed all data collected and refined data as per objectives and came up with a strong hypothesis.

5. Results and Discussion

5.1. Findings

(These findings answer the research questions that we had formed in the beginning.)

Limitations:

TABLE 8: Methodology Part 2.

WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12
Secondary case studies and survey:	Visited Primary case studies and interviews:	Analysis of case studies and observations:	Drafting conclusions:	Refined conclusion, Survey analysis:	The draft report and finalized conclusion:
Explored case studies online, within the country as well as international case studies. - National Museum Delhi + - MOG MOMA + Van Gogh Museum	Visited museums to experience it first-hand. - IME and - NGMA.	Comparison between case studies- high tech and low tech/ interaction, and senses affected. Conducted survey analysis.	Analysed data collected. Drafted conclusion, based on data analysis.	Redefined and reworked based on deeper research collected and in-depth analysis.	Finalized all data as well as the conclusion to come up with a final draft of the report.

- **Art Transformation Scope:** Recognizes the study’s inability to fully encompass the vast, rapid changes in the art world, potentially missing specific nuances.
- **Technology Constraints:** Acknowledges limitations in replicating certain artistic elements authentically through technology.
- **AI Implementation Challenges:** Considers challenges like cost and ethics in integrating AI into museums for enhanced experiences.

Strengths:

- **Comprehensive Exploration:** Despite limitations, offers a broad understanding of evolving art forms and their impact on exhibition spaces in art museums.
- **AI Innovation Potential:** Highlights AI’s versatile applications for enhancing visitor experiences and its future-oriented perspective.
- **Futuristic Outlook:** Embraces cutting-edge technology, showing awareness of emerging trends in the art exhibition landscape and utilizing tools like AI, VR, and MR.

5.2. Guidelines and Recommendations

- Guidance for the next steps that move towards a greater focus on interactivity, in its varied forms, Such as interactive storytelling with AI.

- Art Museums are meant to be designed for everyone and be all-inclusive, and for all ages.
- Using diverse media, visitors are encouraged to engage with displays in bodily, sensorial, emotive, and immersive ways. Introduce tools like VR and MR to accomplish this.
- Use of AI to create AI-enabled smart guidance systems, Spatial Immersive displays, and AI chatbots.
- Interactives are to be both manual (where visitors are invited to touch, move, push, pull, or feel three-dimensional models and aids) as well as electronic (where visitors undertake activities on touch-screen computers or listen to and view audio-visuals).
- For visitors with visual impairment sensory aids are provided, including the use of three-dimensional painting touch boards in guided tours to turn, as Classen and Howes put it, ‘the skin into a tactile eye’ [?].
- Workshops with learning assistants give school groups, as well as more general visitors, the opportunity to handle ‘real’ objects as well as models and replicas. This is set within a wider educational remit of ‘hands-on learning’ [?] describing learning with objects as offering children: The opportunity to use all their senses to explore and respond to what is around them. This sensory experience of touch, sight, smell, sound, and sometimes taste, encourages new ideas, feelings, and thoughts, which spark curiosity, questioning, exploration, and discovery.

6. Conclusion

6.1. Future Prospects

Further research can be conducted to answer more in-depth questions found during the study and create assertive guidelines for those who already work with technologies in museums as per the ever-expanding technological advances with time.

In this study the senses targeted were hearing and touch, however, other senses such as smell and taste can be further investigated, such as one museum that had a cuisine along with music in one of the rooms to stimulate the experience more. Another research question that can be probed is “Is food an art form?”. Further, we can also

investigate developing technologies to enhance the space, as well as how far can AI be utilized and its continuous development.

The limitations of lack of time, and small sampling size as well as resources put a hold on this study and brought about research gaps for further probing.

6.2. Inference

This paper talks about the AI implementation through sensory design in Art museums to increase the consumption of art, after conducting theoretical research through previous findings working through Live case studies and conducting surveys. We have concluded that art both modern and historical can be interpreted through technology giving us a new perspective to perceive it, through the help of sensory design techniques. Some of the technology such as advanced AI and machine learning can be used to enhance the visitor experience and learn visitor behaviour of the public and can also benefit visitors who are disabled, coexisting alongside one another, and enabling museum visits more accessible.

It is important to understand that while including technology and transforming/ re-designing the museum space in a broader term, we don't exclude the original design, by preserving the initial design of art museums as we add our contributions regarding the changes in the current growing world and can prove the idea of allowing AI technology to Co-exist with Art.

The final major objective of this research was to emphasize how technology such as AI plays a role in promoting the physical, cognitive, sensory, and, in short, cultural accessibility of museum exhibitions. On the one hand, technology supports the dissemination of information about the exhibits, and on the other, it helps to create an inclusive museum that provides exceptional learning experiences and enhances the experience of disabled visitors.

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