

From Exhibits to Immersive Experiences: Digital Initiatives at Science City Kapurthala

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ABSTRACT

Historically, Science Museums rely on traditional exhibits like information panels, dioramas, models, and visual representations to engage visitors and enhance mass appeal and participation in science. Science museums are undergoing a digital transformation, shifting from traditional exhibits to immersive, technology-driven experiences. Pushpa Gujral Science City (PGSC), Kapurthala, has embraced this change by integrating advanced technologies such as virtual reality (VR), augmented reality (AR), projection mapping, and interactive displays. This paper explores PGSC's digital initiatives, their impact on visitor engagement, and the challenges encountered during this transition. Drawing on global trends and comparative analyses, including efforts by the Science Museum Group (SMG) in London and the National Council of Science Museums (NCSM) in India, the study highlights the importance of blending physical and digital exhibits (phygital) to enhance science communication. Recommendations focus on addressing challenges like high costs, digital accessibility and data privacy to ensure sustainable and inclusive digital transformation in science museums.

KEYWORDS: Immersive gallery, Digital gallery, Science Communication, Traditional Exhibits, Digital Era, Science Museum, Digital Technologies

1. Introduction

Pushpa Gujral Science City (PGSC) has been set up with the objective of inculcating a scientific temper and promoting the spirit of learning amongst students and the general public. PGSC has

undertaken Science popularisation in Mission Mode to supplement formal science education through non-formal means. With over 75 lakh visitors and an annual average of 3.5 lakh visitors, PGSC has become a hub for science popularisation through interactive exhibits, simulators and educational shows.

Science Museums refer to places where visitors, especially students, learn scientific concepts through interactive exhibits, standalone models and information panels. The exhibits in the Science Centre enable students to understand textbook concepts through their working models and hands-on activities. Thus, Science museums play a crucial role in educating and engaging the public. However, it was observed that such traditional exhibits often struggle to maintain visitor interest over a period of time due to their static nature.

Traditional science museums rely on static exhibits, models and information panels to communicate scientific concepts. However, the rapid advancement of technologies such as AI, VR, AR, and high-end sensors has revolutionised science communication, enabling more immersive and engaging experiences. Thanks to digital technologies, museums can enhance visitor engagement and provide more immersive and interactive experiences (Yang and Guo, 2023).

This paper examines PGSC's digital initiatives, their impact on visitor engagement and the challenges of transitioning from traditional to digital exhibits. It also draws parallels with global efforts, such as those by the Science Museum Group (SMG) and the National Council of Science Museums (NCSM), to provide a comprehensive perspective on digital transformation in science museums.

2. Traditional Exhibits vs. Digital Experiences

Conventional exhibits feature hands-on displays, standalone models or dioramas, and informational panels, while digital exhibits utilise interactive touchscreens, virtual reality headsets, advanced projectors, and sensors. Each type of exhibit—whether physical or digital—offers unique benefits and drawbacks. Encountering a tangible model or interactive display can help Visitors Bridge the concepts found in textbooks with real-world applications,

stimulating both innovation and creativity. Such environments also encourage visitors to exchange thoughts and insights, facilitating connections and building a sense of community. In contrast, digital exhibits deliver a captivating, multisensory experience by leveraging state-of-the-art technology.

3. Need for Digital Experiences in Science Museums

Adopting digital strategies is crucial for science museums to maintain their significance in an increasingly digital world. They help museums attract new audiences, amplify programs and support income generation. Implementing digital strategies allows museums to curate their collections online, making them accessible globally. By 2002, many museums were already seeing virtual visitors to their websites outnumbering those attending in person. These shifts -both within the institution and in the digital realm - present various challenges for educators and curators. Central to these challenges are fundamental questions: What sets learning in museums, science centres and galleries apart, and in what ways might these unique qualities transform as digital technologies become more prevalent? By leveraging online resources and emerging technologies, such as augmented reality, museums can make their collections accessible to a global audience and create dynamic, interactive experiences. However, this transition to digital formats also requires consideration of the irreplaceable aspects of traditional museum visits and the evolving function of on-site learning as technological advancements continue.

4. Digital Initiatives at Science City Kapurthala

Science City was opened to the public with exhibits on basic Sciences and theatres on Space, 3D, laser, and flight simulation. The initial displays were primarily physical, focusing on core principles of mechatronics, optics, mathematics, electricity, and sound through interactive and engaging experiences. In later phases, new galleries were introduced, blending digital and sensor-based technologies with standalone exhibits:

- **Virtual Reality Gallery (2009):** This gallery offers entertainment and education for all ages, featuring Virtual Game Stations and shadow-based exhibits. Participants

step into computer-generated realities, with their images superimposed into virtual scenes via video cameras. The Shadow Garden features six interactive exhibits that utilise shadows to trigger dynamic responses, thereby enhancing visitor engagement.

- **Panorama on Life Through the Ages (2012):** Housed in an 80-foot dome, this gallery combines 2D and 3D models with sensor-based interactivity, tracing evolution from the Big Bang to the present. Divided into 16 sections, it uses sensor-activated models and massive background paintings to create an exhilarating journey through time.
- **Climate Change Theatre (2014):** A multisensory theatre with synchronised digital content on flat and dome-shaped screens, raising awareness about global warming. Special light and sound effects accompany the narrative, highlighting the impact of climate change and encouraging a reduction in carbon footprint.
- **Immersive Show on Healthy Ecosystems (2024):** "Eco Echoes" transports visitors to diverse ecosystems using 360-degree projection mapping, scent emitters, and temperature controls. This groundbreaking experience offers unprecedented exploration and education, blending scientific wonders with immersive entertainment.
- **QR Code-Based Demonstrations:** QR codes at all exhibits link to YouTube videos that explain scientific concepts and the workings of the exhibits, enabling self-paced learning via smartphones.
- **Social Media:** In line with its digital presence, Science City maintains active profiles on Facebook, Twitter, Instagram, and YouTube, sharing updates and expanding its reach to a broader audience.
- **Digital Feedback System:** Touch screen kiosks at theatre exits and the Science City exit collect real-time visitor feedback to enhance services and offerings.

5. Tools Used

1. PGSC ticketing software- To ascertain the number of visitors during the period from 2023 to 2024

2. Feedback application Kiosk - To rate the experience of visitors after visiting the traditional and digital gallery. The feedback form was evaluated using a Likert scale 1 (poor) to 5 (Excellent). The data was analysed using a graphical presentation.

6. Impact of Digital Initiatives

• Visitors Engagement

The Immersive Show on Healthy Ecosystems was opened to the public in June 2024. The marketing campaign for the new facility was conducted through PGSC social media handlers and print media. It was observed that there was a considerable increase in visitor engagement after this period. The analysis of the increase in visitor flow is illustrated in Fig. 1.

• Visitors Satisfaction

The study was conducted to record the experiences of visitors after visiting a traditional gallery with static panel-based exhibitions (Birds Gallery) and a digital immersive gallery (Immersive Show on Healthy Ecosystems). Data from approx. Five thousand visitors were recorded during the period from February 2025 to August 2025. The study reveals that more than 80% of the visitors were attracted to the digital experiences. In contrast, only 40% liked the traditional panel-based experiences. The analysis of the change in visitors' satisfaction levels during the digital experience compared to the static exhibition is illustrated in Figs. 2 and 3.

7. Challenges

While digital initiatives have enhanced visitor engagement and satisfaction levels, they bring notable challenges:

- **Digital Divide:** Inequalities and differences between rural and urban areas restrict access to digital experiences, thereby risking the widening of the participation gap.
- **High Costs:** Expenses related to infrastructure, maintenance, and the rapid pace of technological obsolescence place significant strain on resources.

- **Data Privacy:** Safeguarding visitor information from cyber threats remains a critical concern in an increasingly connected environment.
- **Overuse of Technology:** Some visitors may seek non-digital, hands-on experiences as a respite from the pervasive technology in their daily lives.

8. Discussion

Science museums are increasingly adopting digital technologies to create more interactive and immersive experiences, enhancing visitor engagement and understanding of complex scientific concepts. However, it is crucial to ensure that the core content of exhibits remains central, with technology serving as a tool to simplify and deepen comprehension rather than overshadowing traditional displays. This approach is supported by research from MDPI and ACS Style (Liu, Q, 2024) which highlights strategies for leveraging digital and immersive technologies to improve visitor satisfaction, behavioural intentions, and overall attitudes.

In line with this, the "Science Museum Group (SMG) comprising institutions like the Science Museum in London, the National Railway Museum in York, and others, has implemented a digital strategy focused on enhancing museum experiences, broadening audience reach, and fostering participation (SMG Digital Library, 2024). SMG's initiatives include relaunching websites, producing STEM-focused digital content, and exploring digital fundraising options such as online donations and crowd funding. Their "Digital Lab" initiative has introduced projects like hack days, 3D digitisation of objects, and virtual reality (VR) experiences to meet evolving audience expectations.

Similarly, the "National Council of Science Museums (NCSM)", an autonomous society under the Ministry of Culture, Government of India was formed on April 4, 1978, is driving the digital transformation of science museums by developing digital content, promoting science through digital media, and establishing innovation hubs. NCSM operates 26 science centres nationwide, playing a pivotal role in advancing science education and awareness through technology.

The future of museum interactives lies in blending physical exhibits with immersive technologies, such as VR, AR, and multimedia installations - a concept often referred to as "phygital" (Jim Richardson, 2024). This hybrid approach enriches storytelling and enhances visitor understanding. However, high costs and time sensitivity pose challenges, particularly for self-sustaining museums with limited funding. This view is supported by Hanna Woodhead in 2023 mentioning that museums have excelled at making their treasures publicly available online (Hanna Woodhead, 2023). However, this entails substantial extra work, requiring trained professionals and often sizable budgets. Solutions include leveraging "Corporate Social Responsibility (CSR)" funds or adopting "Public-Private Partnerships (PPP)" models, as demonstrated by PGSC's robotic dinosaur gallery, which was successfully implemented through PPP. In addition, having quarterly/half-yearly or annual academic, industry interactions, events and workshops can further encourage exchange of ideas and create opportunities for funding. Lending facilities and infrastructure as design studios or idea incubation centres for academia and industry, can further open non-conventional revenue streams.

The "5Es Experience Model" (Conifer Research)—Entice, Enter, Engage, Exit, and Extend—offers a framework for integrating technology effectively. The "Engage" and "Extend" stages are particularly suited for digital interactions, such as interactive displays and post-visit digital experiences via websites, apps, and social media (Grace Harms, 2018).

Despite progress, challenges remain. Personalised systems must address privacy concerns and ensure seamless cross-device functionality. Interactive displays should accommodate individual preferences, and data accuracy must be maintained across all platforms. These issues, highlighted by Yu-Chang Li, Alan Wee-Chung Liew, and Wen-Poh Su (Yu-Chang Li, 2012), underscore the need for continued innovation in digital museum development.

Museums must, therefore, strike a balance between traditional and digital approaches, leveraging technology to enrich storytelling while addressing practical and ethical challenges to create inclusive, engaging, and sustainable experiences.

9. Conclusion

The current study underscores the necessity for science museums to transition from solely physical exhibits to a hybrid model that integrates physical and digital technologies, thereby enhancing visitor engagement and delivering immersive, interactive experiences. By effectively leveraging digital tools, PGSC has not only elevated the learning experience but also established itself as a global benchmark for future science museums. PGSC's dedication to digital transformation highlights the transformative potential of technology in science communication.

The study recommends that scientific galleries prioritise the seamless blending of physical and digital experiences to ensure effective communication. Addressing existing challenges will further position museums as pioneers in immersive science education, solidifying their role as leaders in the field.

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