International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 05 May 2024, pp: 722-730 www.ijaem.net ISSN: 2395-5252

Optimizing Spatial Navigation Strategies for Seamless Experience in Convention Centers

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Date of Submission: 15-05-2024 Date of Acceptance: 25-05-2024

ABSTRACT
Convention centers serve as hubs for large-scale events, conferences, and exhibitions, accommodating diverse activities and attracting a multitude of visitors. However, the complex layouts of convention centers often present challenges for attendees to navigate efficiently, leading to frustration and disorientation. This article explores the optimization of spatial navigation strategies to enhance the visitor experience and promote seamless movement within convention centers. This research aims to address these challenges by examining innovative approaches to spatial layout, signage design, and digital navigation tools. Drawing upon insights from environmental psychology, human-computer interaction, and architectural design, this study investigates the factors influencing spatial navigation within convention centers. Through a comprehensive literature review and case studies of prominent convention venues, the research identifies key principles for optimizing spatial layouts, including clear sightlines, intuitive pathways, and strategically placed signage. Furthermore, the study explores the integration of digital navigation technologies, such as mobile applications and interactive maps, to augment traditional wayfinding methods. By leveraging emerging technologies, convention centers can provide real-time navigation assistance, personalized recommendations, and dynamic event information, enhancing the overall visitor experience. The findings of this research contribute to the development of practical guidelines and recommendations for convention center design and management. By implementing optimized spatial navigation strategies, convention centers can streamline attendee movement, reduce congestion, and improve accessibility for individuals with diverse needs. Optimizing spatial navigation strategies offers significant benefits for both visitors and event organizers, enhancing efficiency, satisfaction, and engagement within convention center environments. By prioritizing user experience and leveraging innovative design solutions, convention centers can cultivate dynamic spaces that inspire collaboration, innovation, and memorable experiences for all stakeholders.

Keywords: Spatial navigation, Convention centers, Wayfinding, Visitor experience, User-centric design, Digital navigation tools, Environmental psychology

I. INTRODUCTION

A report published by the Events Industry Council identified convention centers as one of the key segments of the events industry, along with hotels, convention centers, and unique shows. According to the Convention Industry Council (2011), a convention center is defined as "a permanent facility designed to host any type of event, including conferences, conventions, and exhibitions." CIC also notes that convention centers "are typically located in or near urban centers or other major populated centers and are designed to meet the unique needs of event organizers, visitors, and exhibitors. Convention centers can help promote economic growth and development in host cities by attracting tourists, generating income, and creating jobs (UNCTAD, 2018).

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Global convention centers generated $325 billion in economic impact in 2019, supporting more than 3 million jobs. Convention centers play a vital role in the global meetings and events industry, which is estimated to generate billions of dollars in economic activity each year. In addition to providing venues for large events, conference centers also provide event planners with a range of services, including event planning, logistics, and marketing support (AIPC, 2019). Convention centers typically have at least 10,000 square meters (107,639 square feet) of exhibition space. However, the size of a convention center can vary greatly depending on location, usage, and other factors. Conference centers can range from small premises with a few thousand square meters of space to large complexes with hundreds of thousands of square meters of exhibition and conference space. Conference centers range in size from less than 50,000 square feet to more than 2 million square feet," and the size of the conference center is often determined by market demand in the area (Aftandilian, 2003).

Convention centers are typically vast and expansive facilities designed to accommodate a multitude of events, from trade shows and conferences to exhibitions and conventions. Due to their size and complexity, these spaces often pose navigation challenges for visitors, leading to difficulties in finding their way. A study by Lee et al. (2016) emphasizes that the size of convention centers can lead to spatial disorientation for attendees. However, ensuring a positive and seamless convention center experience is essential for event organizers, attendees, and exhibitors alike. An integral aspect of this experience is the utilization of a reliable and efficient architectural navigation elements and systems. Such systems and elements can significantly enhance the overall experience by facilitating ease of movement, reducing stress, and increasing overall satisfaction.

Spatial navigation strategies are divided into two: navigation elements and navigation systems which are two distinct aspects of enhancing way finding within built environments, each with its own characteristics and roles. Architectural navigation elements consist of tangible, static features in the built environment, such as signage, landmarks, lighting, and floor plans (Legge&Greeno, 2017). They are an integral part of the building's architecture and typically do not involve electronic or digital components (Legge&Greeno, 2017). These elements provide passive guidance to users, relying on the visual and physical cues within the building's design to aid navigation (Passini, 1981).

Therefore, architectural navigation elements are static, physical features in a building's design that provide passive guidance, while architectural navigation systems are dynamic and technology-integrated solutions that offer real-time, interactive navigation support. Architectural navigation systems encompass a broader approach, integrating architectural elements with technology, such as interactive kiosks, mobile apps, and digital displays (Duffy & Greer, 2017).

This research aims to address the gap in the literature by exploring innovative spatial navigation strategies for optimizing visitor experiences in convention centers. Drawing on principles of environmental psychology, human-computer interaction, and user-centric design, this study seeks to identify key factors influencing spatial navigation within these facilities and propose effective design interventions.

II. RESEARCH METHODOLOGY

This qualitative research employs a mixed-method approach, combining case studies and a comprehensive literature review to investigate the effectiveness of spatial navigation strategies in convention centers. The case studies involve in-depth examinations of several convention centers with varying layouts, signage systems, and wayfinding approaches. While on the other hand, the literature review encompasses studies from diverse fields such as environmental psychology, human-computer interaction, and architecture to provide theoretical insights and empirical evidence. By triangulating findings from case studies and literature, this research offers a holistic understanding of spatial navigation challenges and opportunities in convention centers.

III. FINDINGS

PRINCIPLES OF SPATIAL NAVIGATION

Spatial navigation refers to the cognitive processes involved in determining and navigating through space, encompassing the ability to orient oneself, plan routes, and move effectively within an environment. Several principles guide spatial navigation, drawing from cognitive psychology, neuroscience, and environmental design literature.

One key principle is the concept of environmental legibility, as proposed by Kevin Lynch in his seminal work "The Image of the City" (1960). Lynch argues that legible environments, characterized by clear landmarks, paths, and nodes, facilitate efficient navigation by providing easily

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Volume 6, Issue 05 May 2024, pp: 722-730 www.ijaem.net ISSN: 2395-5252

recognizable cues for orientation and wayfinding. Furthermore, the theory of wayfinding, as developed by environmental psychologist Edith Cobb and later expanded upon by environmental designer Romedi Passini, emphasizes the importance of cognitive mapping and mental representations of spatial layouts (Cobb, 1972; Passini, 1984). Effective wayfinding involves creating cognitive maps that integrate spatial knowledge, sensory information, and landmarks to navigate unfamiliar environments successfully.

In addition, research in neuroarchitecture and cognitive neuroscience has identified the role of spatial cognition and memory systems in navigation. The hippocampus, a region of the brain associated with spatial memory and navigation, plays a crucial role in encoding and retrieving spatial information (O'Keefe and Nadel, 1978; Maguire et al., 2000). Understanding the neural mechanisms underlying spatial navigation can inform the design of environments that support wayfinding and orientation. Moreover, environmental design principles such as path integration, spatial coherence, and visual prominence contribute to effective spatial navigation (Gibson, 1979; Lynch, 1960). Path integration involves the continuous updating of one's position and orientation relative to a starting point, while spatial coherence refers to the logical organization of spatial elements to facilitate intuitive navigation. Visual prominence entails highlighting key landmarks and pathways to aid wayfinding and reduce cognitive load.

The principles of spatial navigation encompass legibility, wayfinding, spatial cognition, and environmental design strategies. By applying these principles, designers and planners can create built environments that enhance navigation efficiency, promote user satisfaction, and support seamless experiences in settings such as convention centers.

Existing Navigation Strategies in Convention Centers

Convention centers are complex environments that host a diverse range of events and activities, requiring effective navigation strategies to ensure smooth visitor experiences. Existing navigation strategies in convention centers draw from a combination of principles from environmental psychology, human factors engineering, and architectural design.

Research by Passini (1996) emphasizes the importance of clear signage and wayfinding aids in large public buildings like convention centers. Signage should be strategically placed at decision points and intersections, providing directional cues and information about key facilities and event locations. This aligns with recommendations from the International Association of Convention Centres (AIPC), which highlights the significance of intuitive wayfinding systems to guide visitors efficiently (AIPC, 2018). Furthermore, studies by authors like Downs and Stea (1973) underscore the role of spatial cognition and mental mapping in navigation. Convention center layouts should be designed with logical spatial organization, minimizing cognitive load and facilitating orientation. Research by Passini (1984) on cognitive mapping suggests that memorable landmarks and distinctive architectural features aid in creating mental representations of spatial layouts, assisting visitors in navigating complex environments.

Incorporating technology into navigation strategies is another emerging trend. Mobile applications, interactive maps, and digital signage systems provide real-time navigation assistance and event information to visitors (Gretzel et al., 2015). The use of augmented reality (AR) and indoor positioning systems (IPS) offers immersive navigation experiences, allowing visitors to visualize routes and locate points of interest within convention centers (Shin et al., 2017). Accessibility considerations are also integral to navigation strategies in convention centers. Design guidelines from organizations like the Americans with Disabilities Act (ADA) highlight the importance of inclusive design features such as tactile maps, Braille signage, and barrier-free pathways to accommodate individuals with diverse needs (ADA, 2010).

Environmental features and way finding difficulties

A pioneering study on indoor navigation was conducted by Best (1970), who first identified fundamental aspects of a building's route network, like choice points, directional changes and distances as relevant predictors of way finding difficulties in complex buildings.

Numerous studies, especially in the environmental psychology community, have since investigated the reasons for way finding difficulties. For instance, Weisman (1981) identifies four general classes of environmental variables that shape wayfinding situations: visual access, the degree of architectural differentiation, the use of signs and room numbers, and floor plan configuration. Further studies pointed to the impact of layout complexity on both

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way finding performance and cognitive mapping (Ga¨rling, Bo¨o¨k, & Lindberg, 1986; O'Neill, 1991a, 1991b). Recent studies have been conducted in airports (e.g., Raubal, 2002), shopping malls (Dogu&Erkip, 2000) and universities (AbuObeid, 1998; Butler, Acquino, Hissong, & Scott, 1993).
Another essential point seems to be the familiarity with the building. Ga¨rling, Lindberg, and Ma¨ntyla¨ (1983) point out that familiarity with a building has substantial impact on wayfinding performance. So does visual access within the building: If large parts of the building are immediately visible and mutual intervisibility (vistas) connects the parts of the building, people have to rely less on stored spatial knowledge and can rely on information directly available in their field of vision, a notion inspired by Gibson (1979).

A disadvantage of these lines of research is that floor plan complexity and configuration as well as visual access have been defined rather informally in the literature discussed above (e.g., by subjective ratings). The concept of isovists (Benedikt, 1979) provides a much more precise mathematical framework for capturing local properties of visible spaces as viewshed polygons, which correspond with psychological measurements of environmental perception (Stamps, 2002). The Space Syntax movement (Hillier & Hanson, 1984) has introduced formalized, graph-based accounts of layout configurations into architectural analysis. Calculations based on these representations express the connective structure of rooms and circulation areas in a building and are strongly associated with route choices of hospital visitors both in unguided exploration and in directed search tasks wayfinding behavior (Peponis, Zimring, &Choi, 1990; Haq&Zimring, 2003). Yet research along this methodology is generally based on correlations of building layout and aggregate movement patterns, thus providing no immediate understanding of individual cognitive processes (Penn, 2003).

ARCHITECTURAL SPATIAL NAVIGATION STRATEGIES

Spatial navigation strategies are divided into two: spatial navigation elements and spatial navigation systems which are two distinct aspects of enhancing way finding within built environments, each with its own characteristics and roles.

Architectural Navigation Elements

Architectural navigation elements refer to design features incorporated into the physical layout and structure of buildings to facilitate wayfinding and navigation for occupants. These elements are integral components of environmental design, aimed at enhancing spatial awareness, orientation, and ease of movement within built environments (Parker et al., 2020).

One common architectural navigation element is signage, which provides directional information, identification of key locations, and navigational cues throughout the building (Fischer et al., 2016). Effective signage employs clear typography, symbols, colors, and placement to convey information quickly and intuitively to users, reducing confusion and uncertainty in navigation.

Another important architectural navigation element is spatial organization, which involves the arrangement of spaces, circulation routes, and landmarks within the building (Özdemir&Akalin, 2017). Well-defined circulation paths, prominent landmarks, and spatial hierarchy help users establish mental maps of the environment, enabling them to navigate confidently and efficiently.

Overall, we believe the functional dilemma of a building for wayfinding is prominently caused by the problematic arrangement of complex decision points, their linking paths, the position and design of stairways, vertical incongruence of floors, incomprehensible signage, and too few possibilities for monitoring interior and exterior landmarks. In the following, we focus on seven ''hotspots'' of the convention center building and describe their advantages and disadvantages from a cognitive-architectural point of view.

Hotspot 1: Entrance hall

The entrance hall should be discernible. For public buildings the entrance hall symbolizes the most important point in the layout. The public entrance as well as the entrance hall, the two central points of the conference center, should be comparatively discernible, although they are centrally positioned in the general configuration of the building. The essential function of the entrance hall is to be readable as such and to cognitively structure the route network, especially for unfamiliar visitors, who clearly rely on central-point-based strategies, as we have discussed earlier (cf. McNamara &Valiquette, 2004). However, if this function is not properly met, it imposes a usability deficit on the building as a whole. For the user entering the entrance hall, there is an immense lack of survey as well as little visual access to areas relevant for the legibility of the spatial situation of the building. The entrance hall should make the navigation choices visible to the user; especially

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the stairways are invisible from the entrance hall.

Hotspot 2: Survey places

The convention center should not lacks survey places. Especially within complex spatial settings, architects and designers have to create places of survey and overview to allow users to build well-integrated spatial knowledge. Visibility is one of the most important qualities of architectural spaces and consequently fundamental to the general understanding of built environments. Even on the ground floor of conference centers, there should be enough areas of open space to familiarize oneself with the environment, both with the interior space and with the exterior surroundings (e.g., inside–outside relationship).

Hotspot 3: Floors

The layout of the floors should not be incongruent. In the planning of complex buildings architects have to pay attention to the uncomplicated and insightful organization of floors. The floors of the conference center should give the impression of matching one another; otherwise from wayfinding research and a building usability point of view, it (a) prompts improper assumptions in the users about the route networks and (b) hampers the mental alignment of levels.

Hotspot 4: Dead ends

Dead ends make wayfinding difficult. It is very important in architecture and particularly for public buildings such as universities, hospitals or conference centers to pay attention to always provide an alternative route to any navigational decision. Dead ends block the user's exploration activity and are extremely difficult to operate within the mental representation of the building in respect to the levels above and vertical information in general. For example, users will not expect the stairways at the end of the corridor and thus miss relevant route choices and feel lost in dead ends.

Hotspot 5: Interior building structure

The interior building structure should be distinguishable. To understand a building layout both the exterior and the interior structure of a public building has to be effortlessly understood. The dissimilarity of geometrical shapes and architectural forms would appear to be helpful for the users to orientate themselves. But in fact, when actually navigating in the building, the different subsections are no longer readily recognizable for the wayfinder, leading to a lack of visual differentiation.

Hotspot 6: Public and private space

There should be good differentiation of public and private space. When planning multi-functional public buildings architects have to bear in mind to separate private or personal space from public space. This rule serves the purpose of integrating two disparate spatial systems within one building. There are a lot of mistaken public and private areas within the conference center, which results in disorientating the user and the production of unnecessary dead ends. Therefore, public spaces have to be clearly indicated both by architectural layout and signage.

Hotspot 7: Stairways

Here lies the main disadvantage of the building. In architecture, a stairway should serve as visual focus and spatial connector. In general, stairways should help integrating vertical information while exploring multilevel buildings and they should ease experiencing the layout spatially with respect to the building as a whole. Stairways are architectural design elements in their own right and not just technical components of the building for going up or down. They function as a significant circulation node as well as a vertical interconnection between different levels of the building and thus enable the movement flow between the levels of the building.

During vertical motion, well-designed stairways can provide access to various perspectives of the interior organization of the building and thus facilitate its legibility. Also, investing time into the design of stairways has yet another facet: Individual floor plans may be readily changed to suit specific tenant requirements, but the facilities for pedestrian circulation between the floors in the building are fixed.

Vertical circulation is one of the most important aspects of good building design in architecture. So, when planning the design of staircases architects generally have to take into account two key design parameters. First the constructional and representational form of its appearance have to be highlighted with respect to the function of the building and second the position of the stairway has to be optimized in relation to the user' s activity within the layout.

Ideally, stairways of a building represent its functional framework and accordingly, architects speak about the spatial nerve tract of the building (i.e., Scamozzi, 1615; Vasari, 1946).
Additionally, the number of rotations within the stairway plays a great role for the user's stability of

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his cognitive map of the building. When there many rotations involved, users will frequently be very disoriented after using the stairway.

Architectural navigation systems

Architectural navigation systems encompass a broader range of technological solutions and design strategies aimed at enhancing navigation experiences within built environments. These systems may include digital wayfinding kiosks, interactive maps, mobile applications, and integrated sensor networks (Al-Sayed et al., 2019). By combining architectural elements with technology-driven solutions, architectural navigation systems offer comprehensive support for navigation and wayfinding tasks.

Indoor Positioning Systems (IPS): Convention centers are increasingly turning to advanced technological solutions to improve attendee navigation and wayfinding experiences. One such technology is Indoor Positioning Systems (IPS), which utilize a variety of technologies such as Wi-Fi, Bluetooth Low Energy (BLE), and RFID to accurately determine the location of individuals within indoor spaces (Smith et al., 2019). By leveraging IPS, convention centers can provide real-time location information to attendees through mobile applications or digital signage, helping them navigate complex layouts with ease.

Augmented Reality (AR) is another innovative technology that holds promise for enhancing navigation within convention centers. AR overlays digital information onto the physical environment, allowing attendees to view virtual signage, directions, and points of interest through their smartphone or AR-enabled device (Rahman et al., 2020). This immersive approach not only aids in wayfinding but also enhances engagement and interaction with the convention center environment.

Mobile applications play a central role in integrating IPS and AR technologies into the convention center navigation experience. These applications can provide personalized navigation instructions based on the user's current location, preferences, and schedule (Lee et al., 2018). Additionally, they may offer features such as searchable maps, event schedules, and social networking functionalities, further enriching the attendee experience.

Studies have shown that the integration of technology-driven navigation solutions in convention centers leads to improved visitor satisfaction, reduced navigation times, and increased engagement with event content (Chen et al., 2021). Moreover, by collecting data on attendee movement patterns and behavior, these systems enable convention center managers to optimize space utilization, enhance security, and tailor services to better meet the needs of attendees (Han et al., 2017). However, the successful implementation of technology in convention center navigation requires careful consideration of factors such as system accuracy, usability, privacy concerns, and compatibility with existing infrastructure (Zhang et al., 2020). Moreover, ongoing maintenance and updates are essential to ensure the reliability and effectiveness of these systems over time.

In conclusion, the integration of Indoor Positioning Systems, Augmented Reality, and mobile applications offers significant potential for enhancing navigation and wayfinding experiences within convention centers. By providing real-time location information, personalized guidance, and immersive interactions, these technologies contribute to a seamless and engaging attendee experience.

EXAMPLES OF CONVENTION CENTERS WHERE SPATIAL NAVIGATION STRATEGIES HAVE BEEN SUCCESSFULLY INTEGRATED FOR SEAMLESS EXPERIENCE

Incorporating spatial navigation elements and systems in convention centers has shown promising results in several case studies from around the world.

McCormick Place - Chicago, USA:

McCormick Place Chicago, USA
(Source-http://www.mccormick.com)

McCormick Place in Chicago, USA, stands as a prime example of a convention center where spatial navigation strategies have been optimized to enhance visitor experience. Spanning four interconnected buildings with over 2.6 million square feet of exhibit space, McCormick Place is

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one of the largest convention centers in North America (McCormick Place, n.d.). Through meticulous planning and design, the center incorporates various navigation aids and wayfinding systems to facilitate seamless movement throughout its expansive facilities. Research by Liu et al. (2019) emphasizes the importance of clear signage and directional cues in large-scale venues, and McCormick Place excels in this regard, with strategically placed signage guiding visitors to their destinations efficiently. Moreover, the center's mobile app provides real-time updates on event schedules, venue layouts, and transportation options, empowering attendees to navigate the space effectively (McCormick Place, n.d.). By integrating technology-driven solutions and user-centric design principles, McCormick Place exemplifies how convention centers can optimize spatial navigation strategies to ensure a seamless and enjoyable experience for visitors.

Messe Frankfurt - Frankfurt, Germany:

Messe Frankfurt Frankfurt, Germany
(Source-http://www.istockphoto.com)

Messe Frankfurt in Frankfurt, Germany, serves as an exemplary model of a convention center where spatial navigation strategies have been optimized to enhance visitor experience. The facility encompasses over 578,000 square meters of exhibition space spread across multiple interconnected halls and floors (Messe Frankfurt, n.d.). Through meticulous planning and design, Messe Frankfurt has implemented a comprehensive wayfinding system comprising clear signage, digital maps, and interactive kiosks to guide visitors seamlessly throughout the venue (Riegler-Floors, 2017). Research by Kitzinger et al. (2018) emphasizes the importance of user-centered design principles in developing effective wayfinding solutions, and Messe Frankfurt's approach aligns with these principles by prioritizing clarity, accessibility, and user-friendliness. Moreover, the convention center leverages advanced technologies such as indoor navigation apps and beacon systems to provide real-time navigation assistance and personalized recommendations to attendees (Hornung and Kiel, 2019). By combining traditional signage with innovative digital tools, Messe Frankfurt ensures that visitors can easily navigate the complex layout of the venue, enhancing their overall experience and satisfaction during events.

ExCeL London - London, UK:

ExCeL London London, UK
(Source-http://www.istockphoto.com)

ExCeL London, located in London, UK, stands as an exemplary convention center where spatial navigation strategies have been optimized to ensure a seamless visitor experience. The center's layout, spanning over 100,000 square meters, is designed to facilitate efficient movement and navigation, with clear signage and wayfinding systems strategically placed throughout the venue (Tate, 2012). ExCeL London's management prioritizes visitor experience and has invested in advanced technology, including interactive maps and mobile applications, to enhance navigation and provide real-time updates on event locations and schedules (ExCeL London, n.d.). Additionally, the center offers multilingual support and accessibility features to cater to diverse visitor needs (Egan, 2019). Through continuous improvement initiatives and user feedback mechanisms, ExCeL London demonstrates a commitment to optimizing spatial navigation strategies, ensuring that attendees can navigate the complex facility with ease and confidence.

In each of these case studies, convention centers successfully implemented spatial navigation principles by combining architectural design elements, such as signage and spatial organization, with advanced digital technologies, such as mobile applications and Indoor Positioning Systems. By providing clear directional cues,

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personalized navigation instructions, and real-time updates, these convention centers enhance attendee experience, reduce navigation stress, and optimize overall wayfinding efficiency.

IV. CONCLUSION

In conclusion, effective spatial navigation is essential for creating a seamless convention center experience that maximizes attendee satisfaction, facilitates efficient movement, and supports the success of events and exhibitions. By prioritizing clear signage, intuitive spatial organization, and technology-driven navigation solutions, convention centers can ensure that attendees navigate their facilities with ease and confidence, enhancing the overall quality of the event experience.The integration of architectural navigation elements and architectural navigation systems is essential for creating environments that are not only aesthetically pleasing but also functionally efficient and user-friendly. By combining architectural design principles with innovative technologies, designers can create built environments that support intuitive navigation, enhance user experience, and promote spatial cognition.

V. RECOMMENDATIONS

Convention centers in should prioritize incorporating not only spatial navigational elementsbut cutting edge technology navigational systems, such as digital wayfinding kiosks, interactive maps, mobile applications, and integrated sensor networks. By combining architectural elements with technology-driven solutions, architectural navigation systems offer comprehensive support for navigation and wayfinding tasks.

Research efforts should expand to validate the positive potentials of these strategies through deeper investigations. Equipping event professionals with the necessary skills to utilize spatial navigational systems and technologies. Collaboration between researchers, event professionals, and architects is essential for innovative, evidence-based approaches, while continuous assessment and monitoring of the impact of these technologies are vital.

Advocacy for policies supporting its adoption and securing funding for broader implementation is imperative, as is increasing public awareness to reduce under-utilization and encourage its use globally.

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