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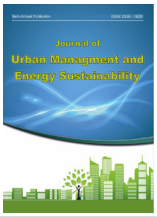

ORIGINAL RESEARCH PAPER

Exploring the Relationship between Sense of Presence and Sense of Place in Dematerialized Architectural Spaces: A Multidisciplinary Review

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ABSTRACT

The creation of a sense of place is a fundamental goal in architecture, shaping how individuals perceive and connect with their surroundings. As architectural practices transition into dematerialized spaces, traditional approaches face challenges in defining and fostering this concept. In Human-Computer Interaction, the "sense of presence" describes the user's experience of being in a virtual environment; however, its relationship to the sense of place remains ambiguous. This review aims to explore and differentiate these concepts within the context of virtual environments by synthesizing insights from architecture, psychology, and cognitive science. A systematic review methodology was employed, drawing from peer-reviewed articles published between 2018 and 2024 across architecture, HCI, and cognitive science databases. Studies were selected based on relevance to multisensory feedback, presence, place-making, and virtual experience design. Data were extracted, thematically analyzed, and synthesized to build a coherent framework linking presence, place, and multisensory interaction. The analysis reveals that multisensory techniques, specifically visual, auditory, and haptic feedback significantly enhance the sense of presence, fostering deeper emotional and cognitive engagement. However, critical gaps persist, including limited cross-sensory integration, a lack of longitudinal studies evaluating the durability of presence, and insufficient inclusivity for diverse user populations. This review provides a conceptual framework advocating for personalized, inclusive, and multisensory approaches to virtual environment design. By bridging architectural theory and HCI, the study highlights the need for sustainable strategies that transform dematerialized spaces into meaningful environments deeply connected to human experience. These findings have significant implications for advancing the use of virtual environments in education, therapy, and entertainment sectors.

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INTRODUCTION

Sense of Place

The concept of "place" is explored extensively across architecture, urban planning, philosophy, and geography. Casey (1993) emphasizes the experiential aspect, viewing place as an extension of bodily existence, while Relph (1976) interprets place existentially, highlighting observer attitudes and intentions. These diverse perspectives underscore the need for interdisciplinary analysis to understand human interaction and the formation of a sense of place within virtual environments (Tab. 1).

Concept of Place in Dematerialized Spaces (Virtual, Cyber)

Virtual and digital spaces lack a unified definition. Early ideas of "cyberspace" (Audoubléja, 1938; Wiener, 1948) became mainstream through Gibson's Neuromancer (1984). Kalay and Marx (2001) outlined eight features of "cyberplace" that parallel physical space, including authenticity, adaptability, and cultural influence. A meaningful sense of place in virtual environments goes beyond technical realism and requires cultural sensitivity. Slater (1999) emphasized the need for embodied experience over passive viewing. Studies show cultural background affects how users perceive and engage with virtual spaces (Bucolo, 2004; Chae, 2023). Chae's VR simulation demonstrated the need for culturally adaptive design. Similarly, Oh et al. (2018) found that cultural factors shape co-presence and emotional engagement. Together, these findings stress the importance of designing virtual places that align with users' social and cultural contexts.

Sense of Presence (SOP2)

Definition of Sense of Presence and Spatial Presence

According to Lombard and Jones (2015), presence is variably defined as feeling, engagement, perception, action, and sense. Regardless of what is being felt, engaged with, perceived, acted upon, or sensed. Another related concept is telecopresence, which is defined as "a form of human co-presence in which "both individuals are physically present at their own local sites" (Zhao, 2003, p. 447 ,Biocca et al., 2003). Schroeder (1995) defines physical presence as "the existence of an object in a specific area of time and space." For example, this text is physically present in front of you right now. In other definitions, the sense of presence is described as a subjective quality of an individual.

The most common type of presence identified in existing definitions is spatial presence, which relates to spaces and environments. Among these definitions, those that describe the feeling, sense, or state of "being there" in a mediated environment are the most prevalent. Witmer and Singer (1998) define presence as "the subjective experience of being in a specific place or environment, even when physically situated elsewhere" (p. 225). Biocca et al. (2003) define "telepresence as the sense of the phenomenon of 'being there,' involving automatic responses to spatial cues and mental models of mediated spaces that create the illusion of location" (p. 459). In some cases, there is a distinction between "being there" in a computer-generated virtual environment and "being there" in a remote, real place. For instance, Sari et al. (2004) state, "Virtual presence means that one feels present in a computer mediated world.

Social Presence and Self-Presence

Social presence refers to the perception of being with others in a mediated environment (Biocca et al., 2003). It includes various aspects such as perceived realism (Gunawardena, 1995), shared space (Lombard & Ditton, 1997), mutual understanding (Sawicki & Kelly, 2000), psychological proximity (Palmer, 1995), and emotional or behavioral involvement (Harms & Biocca, 2004). These perspectives highlight its complex, multidimensional nature, encompassing both human and virtual representations (Lee, 2004; Short et al., 1976). Self-presence describes how users

perceive their digital representations, like avatars, in mediated environments. Ratan (2013), building on Biocca (1997), Lee (2004), and Damasceno's framework (1999), identifies three layers: the prototypical self (body schema), the core self (emotion driven), and the extended self (identity related). These dimensions capture how media use can evoke bodily, emotional, and identity based self awareness.

Presence in Dematerialized Spaces (Virtual, Cyber)
Presence in virtual environments involves the user's mental perception of existing within a digitally mediated location (Slater, 1999). While researchers acknowledge differences between real and virtual places (Benedikt, 1991; Coyne, 1999), defining features that universally generate a sense of place remain elusive. This review investigates the intersection of sense of presence and sense of place, specifically examining multisensory techniques' roles in enhancing user engagement. The goal is to provide an integrated understanding from architecture, HCI, psychology, and cognitive science, addressing existing gaps and guiding future advancements in applications such as education, therapy, and entertainment.

Table 1: Models of Sense of Place in Environmental Studies.

Model	Description
Ralph's Model of Place Identity	A phenomenological and holistic approach to place identity consisting of three main components: Physical conditions, activities offered by the place, and meanings attributed to the place.
Gustafson's Triadic Model of Place Meaning	A comprehensive model introduced in 2001, encompassing three main poles: Self (life, path, feelings, activities, personal identity), Environment (physical features, environmental events, type and location of the place), and Others (perceived personalities, behaviors, social relations).
Jorgensen and Stedman's Concept (Sense of Place as Attitude)	Proposed in 2001, suggesting that many interpretations of sense of place can benefit from considering it as an attitude. It includes cognitive and behavioral variables with three main elements: beliefs about the relationship between the individual and the place, feelings towards the place, and exclusive behavior towards the place compared to alternatives.

MATERIALS AND METHODS

This systematic review investigates the relationship between the sense of presence and sense of place in virtual environments, with a focus on the role of multisensory techniques and design strategies. The methodology followed four phases: (1) literature search, (2) inclusion and exclusion criteria, (3) data extraction, and (4) thematic analysis. A comprehensive search was conducted across Google Scholar, IEEE Xplore, PubMed, and ACM Digital Library, targeting peer reviewed articles, conference papers, and systematic reviews published in English between 2018 and 2024.

Keywords included "sense of presence," "sense of place," "virtual environments," "multisensory techniques," "HCI," "VR design," "emotional engagement," and "interaction techniques," using Boolean operators and filters to ensure relevance and quality. The search process was documented systematically, resulting in over 2,000 initial records. After applying screening criteria, 50 studies were selected. Data were

extracted using a standardized form capturing study objectives, methodologies, sensory modalities, findings, and research gaps. The extracted data were compiled into a comparative table to support thematic analysis and synthesize insights on how multisensory design influences presence and place in virtual settings (Tab. 2).

Table 2: Comparative Analysis: Key Studies, Methods, and Findings.

Being there again – Presence in real and virtual environments and its relation to usability	J. Brade, M. Lorenz, M. Busch, N. Hammer	Compares sense of presence in real vs. virtual environments and its impact on usability.	Experimental comparison between real and VR envi-ronments with user navigation tasks.	Virtual environments can effectively replicate presence and user experience similar to real environments, enhancing usability.	2017
A survey of presence and related concepts	R. Skarbez, F.P. Brooks, Jr., M.C. Whitton	Explores the de-velopment and conceptualization of presence in virtual envi-ron-ments.	Literature review on presence and its applications in VR.	Sense of presence is critical for creating effective VR experi-ences, influencing perception, and enhancing user en-gagement.	2017
Factors affecting sense of presence in VR social envi-ronment	S Riches, S Elghany, P Garety	Investigates factors influencing pres-ence in VR social settings.	Qualitative study involving user feedback and observa-tions.	Social interactions, immersion, and en-vironment fidelity are key factors en-hancing presence in VR social spaces.	2019
Saliency in VR: How do people explore virtual environments?	V Sitzmann, A Serrano, A Pavel	Analyzes user be-havior and atten-tion in immersive VR spaces.	Behavioral analysis of VR user interactions.	User engagement in VR is influenced by visual saliency and environmental fac-tors, affecting the sense of presence.	2018
The impact of per-ception and pres-ence on emotional reactions	J Diemer, GW Alpers, HM Pe-perkorn, Y Shiban	Investigates emo-tional responses related to percep-tion and presence in VR.	Review of VR emotional response studies.	Presence in VR sig-nifi-cantly impacts emotional reactions, enhancing user ex-perience and en-gagement.	2015
The Avatarm: In-teracting in the Physical Metaverse via Ro-botics, Diminished Reality, and Hap-tics	D Prattichiz-zo	Examines the rep-lication of virtual interactions in the physical world, enhancing pres-ence through ro-botics.	Technical explo-ration of robot-ics and dimin-ished reality in enhancing vir-tual presence.	Enhanced sense of presence through physical replication of virtual interac-tions using robotic arms.	2024
Beyond Realism: Rethinking Presence in Virtual Environments for Abstract Concept Learning	D Babe-rowski, T Leonhardt, L Lilienthal	Investigates presence in VR for ab-stract learning con-texts, challenging traditional realism.	Experimental study on ab-stract VR learn-ing environ-ments versus traditional real-istic approach-es.	Presence can be enhanced even in abstract virtual con-texts without relying on realism.	2024

WaterForm: Alter-ing the Liquid to Generate Multi-sensory Feedback for En-hancing Im-mer-sive Environ-ment	IC Chen, HC Chang, CY Hung, CY Lin	Explores the use of liquid-based multi-sensory feedback to en-hance immer-sion in virtual en-vi-ronments.	Experimen-tal study on tactile and visual inte-gration using water-based feedback.	Multisensory feed-back using liquid elements significant-ly enhances user engagement and immer-sion.	2024
Pseudo-walking Sensation by An-teroposterior or Lateral Gal-vanic Vestibular Stimula-tion and Synchro-nous Foot-sole Vibra-tions	T Oyama, K Aoya-ma, T Amemiya	Investigates the creation of walk-ing sensations in virtu-al spaces using multisenso-ry stimulation.	Experimental setup involving vestibular and tactile feedback to simulate walking sensa-tions.	Realistic walking sensations enhance presence through integrated vestibu-lar and tactile stimu-lation.	2024
iVR-fNIRS: study-ing brain func-tions in a fully immersive virtual environ-ment	K Peng, Z Mous-savi, KD Karu-na-karan	Explores the neu-ral impacts of mul-tisensory immer-sive VR environ-ments.	Study using fNIRS to analyze brain activity in response to multisensory VR stimuli.	Multisensory VR environ-ments show significant effects on brain function relat-ed to presence.	2024

FINDINGS AND DISCUSSION

Key Themes

Through this systematic review and analysis, several key themes emerged that illustrate how multisensory techniques impact the sense of presence and sense of place in virtual environments. Findings also highlighted significant gaps that need to be addressed to advance our understanding and design of these virtual experiences. (Fig. 1)

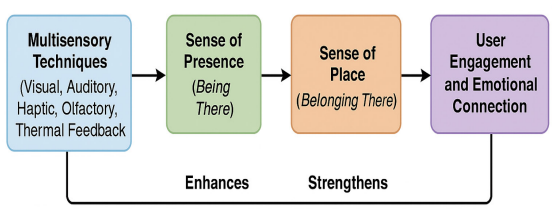

Figure 1: Conceptual Relationship Between Multisensory Techniques, Sense of Presence, Sense of Place, and User Engagement in Virtual Environments

Multisensory Feedback Enhances Engagement

A dominant theme across the studies is the role of multisensory feedback—such as visual, auditory, and haptic inputs—in enhancing user engagement and immersion. These sensory elements are critical for creating a strong sense of presence, making the virtual environment feel more realistic and compelling.

Emotional and Narrative Design

Emotional engagement and narrative-driven design are essential for fostering a sense of place in virtual environments (Gorisse et al., 2023; Ryan, 2021). Adaptive storytelling techniques dynamically adjust narratives based on user interaction and affect, deepening emotional resonance and sustaining immersion (Gorisse et al., 2023). Real-time affective computing, using physiological and behavioral signals, allows VR systems to adapt content complexity and emotional tone, enhancing presence and personalization (Yoon

et al., 2021; Wei et al., 2025).
Recent work by Wei et al. (2025) showed that cognitive load can be predicted in real-time using multimodal physiological markers in VR, enabling environments to respond to users' mental states without prior calibration. Similarly, emotion-adaptive environments have been found to increase user engagement, satisfaction, and memory retention (Frontiers in Psychology, 2021; Frontiers in Virtual Reality, 2022). Agency further modulates emotional involvement; McGivney et al. (2025) demonstrated that perceived control over the environment correlates with positive affect but, if excessive, can detract from cognitive focus. In therapeutic contexts, VR interventions incorporating emotional design principles improved quality-of-life outcomes among older adults with serious illnesses, particularly when structured support and user training were provided (Stanford Research Group, 2025). Collectively, these findings emphasize that emotional and narrative design must be central to VR development. By integrating adaptive storytelling, affect-driven feedback loops, and agency calibration, designers can create emotionally responsive environments that strengthen place attachment and user engagement (Yoon et al., 2021; Gorisse et al., 2023; Wei et al., 2025).

Technical Barriers and Optimization Strategies (in VR Design)
Persistent technical challenges such as latency, motion sickness, and rendering complexity undermine immersion. Latency above 30 ms significantly reduces user performance and comfort (Brunnström et al., 2020). Recent advances in AI, foveated rendering (FR), and edge computing offer solutions. AI can dynamically adjust content and system load (Tadikonda, 2025), while FR enhances visual quality with lower computational demand (Nyamtiga et al., 2024). When combined with edge computing, these techniques reduce delays and maintain performance across varying network conditions (Shi et al., 2020).
Challenges remain, including the need for ultra-precise eye tracking (Koulieris et al., 2016) and ethical concerns around algorithmic bias and data privacy (Raji et al., 2020). Moreover, the long term psychological effects of hyper realistic environments are underexplored (Slater & Sanchez-Vives, 2016).

Interaction Techniques and Social Presence
The importance of interaction design, particularly in supporting social presence, was emphasized across the reviewed studies as a critical factor in fostering a sense of place within virtual environments. Techniques such as gesture-based controls and AI-driven feedback were found to enhance the dynamism and emotional engagement of virtual spaces. The frequency and absolute occurrence (Out of 50 studies) of key themes and gaps are visualized in Figure 2, highlighting both concentrated research areas and underexplored dimensions within the field.

Research Gaps
- Limited cross-sensory integration: Few studies explore combined sensory modalities beyond vision and sound.
- Lack of longitudinal impact studies: Long-term effects of VR on behavior and cognition remain poorly understood.
- Insufficient Inclusivity for Diverse Populations: VR designs often overlook diverse user needs across ability and culture.
- Weak evidence on real world skill transfer: The translation of VR-based learning to real-world performance lacks empirical support.
- Underexplored sensory modalities (e.g., Olfactory, Thermal): Olfactory and thermal feedback remain underutilized.
- Technical optimization: Latency and interface design continue to hinder experience quality.

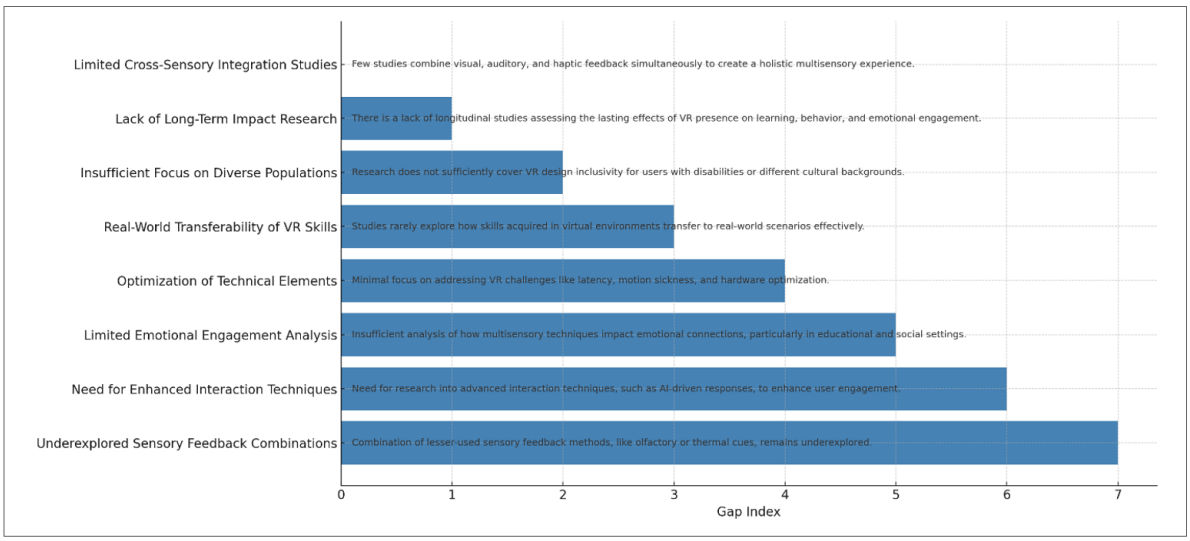

Figure 2: Visualization of Identified Gaps in Multisensory Techniques and Presence Findings.

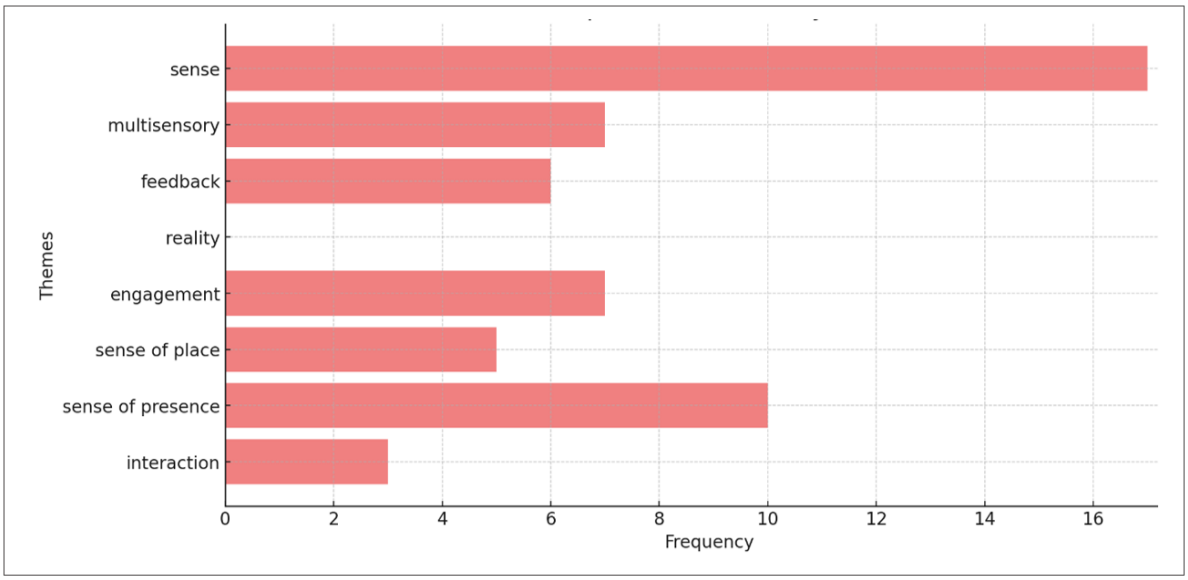

Figure 3: Occurrences of Specific Themes in Systematic Reviews.

CONCLUSION AND RESULTS

Integrated Thematic Analysis and Critical Evaluation

A systematic thematic synthesis of 50 interdisciplinary studies spanning human computer interaction (HCI), cognitive psychology, architecture, and immersive media, was conducted to investigate how multisensory techniques shape the interrelated constructs of presence and place in virtual environments. Methodologies included controlled VR experiments, physiological monitoring (e.g., fNIRS, EEG), self report measures, and behavioral observation, reflecting a diverse but methodologically rigorous body of work. Four dominant and recurring themes emerged: multisensory feedback, emotional engagement, narrative design, and interaction

techniques. These elements were consistently associated with immersive responses across sensory, affective, and cognitive domains. Multisensory feedback particularly when combining auditory, haptic, and visual modalities was shown to enhance the salience of virtual experiences and promote embodied presence. Emotional engagement, often facilitated through affect-driven design, emerged as a key mediator for deeper connection and memory encoding. Narrative structures that adapted in real time to user feedback or biometric inputs were particularly effective in sustaining user attention and fostering place attachment. Crucially, the analysis confirmed that spatial presence alone, while essential for immersion is insufficient to cultivate a full sense of place. High quality studies demonstrated that meaningful place making in virtual environments requires the integration of culturally relevant content, social presence, and affective responsiveness. For example, adaptive VR systems that modified environmental elements in response to emotional cues significantly outperformed static designs in producing long-term engagement and self-reported place-making.

By contrast, studies limited to a single sensory modality (typically visual), with short exposure durations or homogeneous participant samples, were less successful in sustaining immersive experiences. Many also relied solely on self report measures without triangulation through physiological or behavioral data, reducing their validity and generalizability.

Technological constraints were also a recurring concern. Latency, motion sickness, and rendering load commonly disrupted immersion. While emerging solutions such as adaptive foveated rendering, AI enhanced personalization, and edge computing hold promise, their integration with affective computing and inclusive design practices remains inconsistent. Additionally, few studies critically addressed the ethical implications of biometric data use, algorithmic bias, or psychological risk in emotionally adaptive systems.

Significant research gaps were identified across three key areas:

1. Cross sensory integration, particularly involving olfactory and thermal stimuli, remains underexplored.

2. Longitudinal studies tracking behavioral and emotional changes over time are scarce.

3. Inclusive and culturally adaptive design is often absent, with minimal attention to accessibility and cross-cultural variability in perception.

Together, these findings underscore the need for a unified, interdisciplinary framework that moves beyond technical optimization to address the emotional, cultural, and ethical dimensions of immersive environments. This approach must account not only for how presence is constructed, but for how users form lasting, meaningful connections to dematerialized spaces. (Fig. 4 and 5) illustrate the synthesized relationship between presence and place, along with emergent priorities for future research and VR design practice.

Case Studies of Multisensory and Emotional Design in Practice

Table 3 summarizes case studies from education, therapy, social VR, and entertainment, illustrating how multisensory feedback and emotional engagement strategies enhance the sense of presence and place. Techniques such as real-time emotional adaptation (Markowitz & Bailenson, 2021; Herrera et al., 2018), multisensory body interaction (Tao et al., 2024; Han & Bailenson, 2024), and graded exposure therapy (Spytska, 2024; Difede & Hoffman, 2003) consistently proved effective. Studies on educational VR (Ratan et al., 2025; Arrighi et al., 2021; Leong et al., 2021) emphasized the importance of interaction design and optimal immersion time, while therapeutic interventions (Roswell et al., 2025) demonstrated clinical efficacy. Research on asynchronous and transformed social VR (Wang et al., 2024; Han et al., 2023) further

confirmed the influence of environmental and nonverbal cues on user engagement. Collectively, these cases highlight the need for integrating sensory richness, emotional personalization, and adaptive interaction models in the design of virtual environments. (Tab. 3)

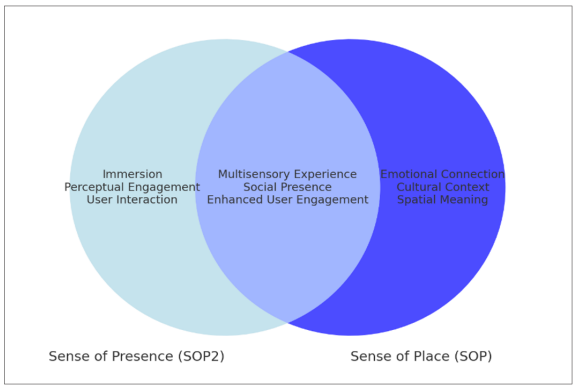

Figure 4 : Relationship between Presence and Sense of Place.

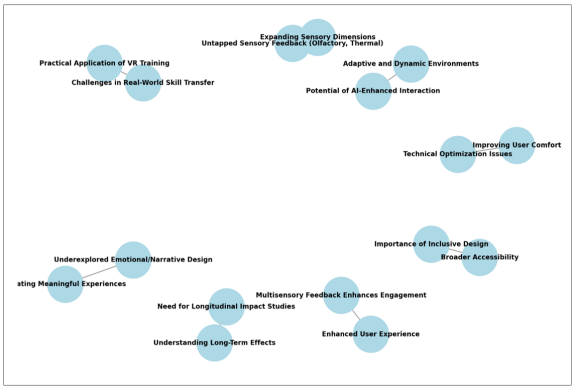

Figure 5: Key Findings and Focus Areas in Multisensory Techniques and Presence in Dematerialized Environments.

Table 3: Case Studies Illustrating Multisensory and Emotional Design in Virtual Environments

Case Study	Domain	Key Techniques	Outcomes
Markowitz & Bailenson (2021)	VR and Emotion Re-search	Multisensory emotion induction and emotion regulation	VR uniquely engages emotional processes compared to traditional media.
Roswell et al. (2020)	Medical Education	VR empathy training for racism, inequity, climate	Improved cultural humili-ty and awareness in healthcare providers.
Herrera et al. (2018)	Social Empathy	VR vs traditional pers-pec-tive-taking for ho-meless-ness	VR perspective-taking led to lon-ger-lasting empat-hetic attitudes and beha-vior.
Tao et al. (2024)	Social VR Interaction	Shared body sensations (haptics)	Increased body ow-nership, empa-thy, and social connectedness.
Ratan et al. (2025)	VR in Education	Duration effects on social presence and learning outcomes	VR enhanced social pre-sence up to 45 minutes; fatigue appeared after.
Difede & Hoffman (2003)	PTSD Therapy	VR graded exposure to trau-matic stimuli	Significant PTSD symptom reduc-tion through VR exposure therapy.
Spytska (2024)	Phobia and PTSD Treat-ment	VR-based cognitive behav-ioral therapy and desensi-tization	Confirmed VR's effective-ness for treating phobias and PTSD.
Arrighi et al. (2021)	Digital Heritage	Transmedia VR storyte-lling and inclusive lo-comotion	Improved user experien-ce and accessibility in heritage VR projects. Improved user experien-ce and accessibility in heritage VR projects.
Al-Ansi et al. (2023)	VR in Education	AR/VR wearable lear-ning platforms	Identified rapid growth of immer-sive education te-chnologies.

Leong et al. (2021)	VR in Inclusive Edu-ca-tion	Skill development through VR environ-ments	VR enhanced engage-ment, knowl-edge reten-tion, and inclusivity.
Conrad et al. (2024)	VR Learning Effec-tive-ness	Active manipulation and constructive creation in IVR	IVR promotes deeper learning when paired with interactive tasks.
Roswell et al. (2025)	XR Behavioral Acti-va-tion for MDD	VR-enhanced Behavio-ral Activation (XR-BA) for depression	VR BA was feasible, safe, and re-duced depression symptoms.
Han et al. (2023)	Longitudinal VR Social Interaction	Avatar design and en-vi-ronmental context in VR classrooms	Avatar realism and envi-ronment openness im-proved presence and engagement.

In Future studies should advance cross sensory integration by combining visual, auditory, haptic, olfactory, and thermal feedback to enhance immersion. Longitudinal research is essential to understand the sustained effects of VR on learning, emotion, and behavior. Inclusive design must address the needs of diverse users, including those with disabilities and from various cultural contexts, to ensure equitable access and engagement. Research on skill transfer from VR to real world scenarios will broaden practical applications. Technical challenges like latency, motion sickness, and interface complexity require continued innovation. Emotional and narrative design should be further explored to deepen user connection, while AI driven adaptations can personalize experiences in real time. Finally, underutilized modalities such as olfactory and thermal cues offer rich opportunities for expanding VR's sensory landscape across domains like therapy, education, and entertainment. Collectively, these directions will support the development of more impactful and inclusive virtual environments.

This systematic review highlights the critical role of multisensory techniques in enhancing the sense of presence and sense of place within dematerialized environments. Integration of visual, auditory, haptic, and other sensory feedback systems has been shown to significantly deepen user engagement, making digital spaces feel more authentic and connected to human experience.Nevertheless, key gaps persist, including limited cross-sensory integration, a lack of longitudinal studies, and insufficient inclusivity for diverse user populations. Addressing these limitations is essential for moving beyond transient immersive effects toward creating environments with lasting emotional resonance. Achieving a meaningful sense of place in dematerialized environments is contingent upon two core strategies: deploying sensory substitution techniques to simulate rich multisensory experiences, and personalizing these environments to reflect individual user preferences and emotional states. Sensory substitution, such as spatial audio, haptic feedback, and olfactory cues, can expand the perceptual richness of virtual spaces, while personalization ensures that environments resonate deeply with users' lived experiences. These approaches not only enhance immediate immersion but also foster enduring place attachment. By synthesizing insights from architecture, psychology, and human computer interaction, this review proposes an integrated framework for designing virtual environments that are technologically advanced, emotionally engaging, and socially inclusive. The findings contribute to advancing the understanding of presence and place in dematerialized spaces, offering pathways for future applications in education, therapy, training, and entertainment. Future virtual environments, grounded in these principles, are positioned to transcend traditional boundaries and create immersive experiences that are profoundly human-centered, personalized, and impactful.

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