

A Systematic Review of Digital Technologies and Their Impact on Interior Architecture

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Abstract: The integration of emerging technologies has profoundly reshaped interior architecture, transforming design processes, user experience, and sustainability practices. However, research remains fragmented across disciplines, highlighting the need for a consolidated synthesis that bridges theory and practice. This study systematically reviews the impact of digital technologies, particularly Virtual Reality (VR), Augmented Reality (AR), Artificial Intelligence (AI), and smart interactive systems, on interior architecture. Following PRISMA 2020 guidelines and the Cochrane Handbook, we conducted a systematic search of Scopus, Web of Science, IEEE Xplore, and ScienceDirect identified 1,246 records. After rigorous screening and quality appraisal using Joanna Briggs Institute (JBI) tools, we included 36 peer-reviewed studies (2018–2025). Four dominant themes emerged: (1) enhanced visualization and perception through VR/AR, enabling improved spatial cognition and client–designer collaboration. (2) user experience and interactivity facilitated by smart and adaptive environments that support multisensory engagement. (3) sustainability and resource optimization, driven by AI-assisted material and energy efficiency. (4) educational and professional applications, where immersive systems enhance digital literacy and design comprehension. Despite their transformative potential, limitations persist regarding scalability, methodological rigor, and cross-cultural generalizability. This review presents an integrated framework for understanding technology-enabled interior design, positioning VR, AI, and smart systems as core drivers of sustainable, human-centered, and innovation-oriented design practice, rather than peripheral tools. Future research should pursue longitudinal, large-scale, and cross-cultural studies, alongside theoretical refinements, to advance both academic knowledge and practical implementation.

Keywords: Interior architecture, design, virtual reality (VR), artificial intelligence (AI), technology, smart environments, sustainability.

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1. Introduction

Interior architecture is undergoing a significant transformation driven by rapid digital progress. Once focused on balancing aesthetics with function, the field now incorporates immersive visualization, responsive systems, and intelligent platforms. VR, AR, AI, and smart sensors now enable adaptive interiors that respond to users and their environments, aligning design with societal goals like sustainability, digitalization, and well-being.

A growing body of research highlights both the opportunities and challenges presented by these technologies. Díaz González et al. (2025) demonstrated that VR enhances spatial cognition and design communication in education, while Xiang (2024) found that immersive interiors foster creativity, reduce stress, and support psychosocial well-being. Rashdan (2024) emphasized the growing focus on sustainability but noted a lack of actionable frameworks, while Al Dwiek and Al Bast (2024) observed that AI applications for material optimization and energy performance remain largely conceptual. Furthermore, Li et al. (2020) proposed multisensory interactions that combine visual, auditory, tactile, cognitive, and emotional aspects; However, most applications remain limited to small experimental setups, raising concerns about scalability, cost-effectiveness, and cultural adaptability.

Despite such advances, the literature remains fragmented. Studies often treat VR, AI, and sustainability in isolation, rely on short-term experiments with small sample sizes, and rarely progress beyond prototype demonstrations. The geographical distribution of research is also uneven, with studies dominated by Asia and Europe while Africa, Latin America, and much of the Middle East are underrepresented. This imbalance raises important questions about the cross-

cultural relevance of digital tools and the disproportionate influence of specific regional priorities. Additionally, a few studies are based on broader conceptual frameworks. Although models like TAM, Human–Computer Interaction, or sustainability transition theory could improve explanatory power, they are rarely applied in interior architecture research.

This study addresses these limitations by performing a systematic review of empirical and design-based research on digital technology in interior architecture. By synthesizing findings across VR/AR, AI, and smart interactive systems, it creates a comprehensive understanding of how these technologies affect visualization, interactivity, sustainability, and education. This review distinguishes itself through its broad scope, methodological rigor, and cross-domain synthesis, moving beyond simple cataloging of studies to highlight overlaps, contradictions, and research gaps.

Three guiding questions structure this review: (1) How do VR and immersive technologies impact spatial perception, design communication, and collaboration? (2) In what ways do smart and interactive systems affect well-being, multisensory engagement, and functional adaptability? (3) How do AI-driven tools support sustainability, adaptive reuse, and circular economy practices? By exploring these questions, the study positions itself at the intersection of digital adoption, experiential design, and sustainable practices, offering insights for researchers, educators, practitioners, and policymakers navigating the digital transformation of interior architecture.

2. Literature Review

The integration of digital technologies into interior architecture has transformed the discipline from a primarily aesthetic pursuit into an adaptive, data-driven, and user-centered practice. To lay a foundation for this review, the literature is organized thematically around four areas: digital transformation in interior design, immersive visualization using virtual reality (VR), adaptive systems powered by artificial intelligence (AI), and smart multisensory environments. Procedural details of the database search and screening processes are outlined in the methodology.

2.1. Digital Transformation of Interior Design

Interior design has traditionally evolved alongside technological innovation, connecting materiality, cultural expression, and human needs (Awad et al., 2016; Al-Fitouri, 2020). However, current research indicates that new tools are redefining the concept of “function” itself, as walls, ceilings, and surfaces become interactive interfaces capable of sensing human presence and mediating multisensory experiences (Al-Mahmoudi, 2015; Grechenig, 2008). Classic works that regarded interior design as both science and an art (Burris, 2014; Demirarslan and Demirarslan, 2020) have gained renewed importance as digital immersion broadens the scope of interior spaces to include sustainability, interactivity, and personalization.

2.2. Immersive Visualization: VR in Interior Architecture

VR has been extensively examined as a medium for enhancing spatial cognition and client–designer communication. Studies confirm that immersive walkthroughs reduce misinterpretation and strengthen design decision-making (Awad et al., 2018; Albayrak-Kutlay and Bengisu, 2025). Albayrak-Kutlay and Bengisu (2025) systematically demonstrated that VR, particularly when combined with neuroscience methods, improves perception and reduces cognitive load in design processes. Similarly, Wu and Han (2023) highlighted the usability and design accuracy of integrated AI and VR systems. However, despite these consistent benefits, most investigations remain laboratory-based or rely on small samples, which constrains claims of real-world applicability.

2.3. Artificial Intelligence and Adaptive Systems

AI is increasingly recognized for its potential to embed personalization and sustainability in design processes. AlShkipi and Zahran (2024) found that AI-driven tools expand creative capacity while incorporating sustainability parameters into design decisions. Likewise, Al Dwiek and Al Bast (2024) emphasized machine learning’s ability to optimize spatial and material choices but noted the scarcity of empirical trials. This finding aligns with earlier observations that designers act both as creative agents and data interpreters (Demirarslan and Demirarslan, 2020). However, unresolved ethical concerns regarding personalization, data use, and transparency persist, and the lack of longitudinal or real-world validations represents a significant methodological gap.

2.4. Smart and Multisensory Environments

The development of smart environments extends the scope of interactivity beyond visualization. Li et al. (2020) proposed a five-senses interaction framework, showing that integrating visual, auditory, tactile, cognitive, and emotional dimensions enhances user satisfaction and environmental quality. Earlier explorations of smart materials and responsive lighting (Bahi El-Din, 2013; Rashdan, 2016) illustrated this potential, including prototypes such as interactive flooring showcased at Expo 2008 (Al-Mahmoudi, 2015). Despite these promising demonstrations, most research has not progressed beyond experimental installations, leaving questions of scalability, affordability, and mainstream adoption (Hassan, 2005).

2.5. Sustainability as a Cross-Cutting Dimension

Across all themes, sustainability emerges as a consistent but underdeveloped concern. Studies affirm technology’s capacity to reduce waste, optimize resources, and improve indoor environmental quality (Rashdan, 2016). However, sustainability frameworks tailored specifically to interior design remain fragmented. Shams Al-Din’s theoretical work, which positions technology as a transformative social force (2009), provides early conceptual grounding, but contemporary studies reveal a lack of integration between AI-driven optimization and interior-specific sustainability criteria (Rashdan, 2024).

2.6. Synthesis of Gaps

Overall, the literature converges on the benefits of VR for perception, AI for personalization, and smart systems for sensory interaction. However, there are contradictions: while Wu and Han (2023) emphasize technical efficiency, Xiang (2025) highlights psychosocial benefits, such as creativity and well-being. In addition, most evidence is prototype-based, methodologically heterogeneous, and geographically concentrated, limiting generalizability. A notable absence is an integrated framework that unites VR, AI, and smart systems within a coherent, sustainability-oriented approach to interior architecture. This review responds to that gap by consolidating cross-domain evidence and proposing a holistic model for technology-enabled, user-centered, and sustainable design.

3. Methodology

3.1. Research Design

This study employed a systematic review approach, guided by the PRISMA 2020 statement (Page et al., 2021), and informed by the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019). This design was chosen to ensure replicability, transparency, and completeness, enabling the critical appraisal of individual studies and the identification of broader trends, contradictions, and gaps across disciplines. This approach is particularly suitable for analyzing the fragmented body of scholarship on digital technologies in interior architecture, a field that intersects with land surveying, architecture, design sciences, and computer engineering.

3.2. Search Strategy

Between January and March 2025, a systematic search was conducted across four interdisciplinary databases: Scopus, Web of Science Core Collection, ScienceDirect, and IEEE Xplore. These databases were chosen to optimize the coverage of peer-reviewed research at the intersection of design and technology. The Boolean search string combined terms related to the discipline (“interior design” or “interior architecture”) with technological keywords (“virtual reality,” or “VR,” “augmented reality,” or “AR,” “artificial intelligence,” or “AI,” “machine learning,” or “smart environments,” or “interactive design,” or “digital technology”). Filters restricted the search to peer-reviewed journal articles published in English from 2015 to 2025. This ten-year period was intentionally selected to balance historical context with recent technological innovation, acknowledging the rapid growth of VR and AI in interior design after 2015.

3.3. Eligibility Criteria

Studies were deemed eligible if they were peer-reviewed journal articles or full conference papers, reported empirical findings or systematic reviews on VR, AI, smart environments, or related digital technologies, focused specifically on interior design or interior architecture in residential, commercial, or educational contexts, and addressed outcomes relevant to user perception, communication, adaptability, sustainability, or design workflows. Exclusion criteria removed non-peer-reviewed materials such as editorials, book reviews, and theses; studies published in languages other than English to preserve interpretive consistency; and research that focused on architecture in general without explicit engagement with interior environments or human–environment interaction.

3.4. Study Selection Process

The database search initially produced 1,246 records. After removing 312 duplicates, 934 records remained for screening at the title and abstract stage. At this point, 742 studies were excluded as irrelevant, largely because they did not address interior design or lacked a technological component. The full texts of the remaining 192 articles were assessed for eligibility, resulting in the exclusion of 156 studies that did not meet the established criteria because they were non-empirical, lacked sufficient methodology, or fell outside the scope of interior architecture. Ultimately, 36 studies satisfied all criteria and were included in the review. The selection process adhered to PRISMA’s four stages of identification, screening, eligibility, and inclusion. To reduce bias, two reviewers independently conducted all screenings and assessments. Any disagreements were discussed and resolved, and a third reviewer adjudicated when consensus could not be reached.

The final selection process is summarized in the PRISMA 2020 flow diagram (Figure 1), which illustrates each stage from initial identification through to the inclusion of the thirty-six studies

3.5. Data Extraction

Data was systematically extracted using a pre-designed Microsoft Excel form. The extracted information for each study included bibliographic details (e.g., author, year), objectives and research questions, methodological design (qualitative, quantitative, or mixed methods), sample characteristics (size, demographics, and professional or educational context), the type of technology investigated (VR, AR, AI, or smart environment), and the key findings, limitations, and recommendations. To minimize subjectivity and ensure reliability, two reviewers independently extracted and cross-checked the data, then reconciled discrepancies through discussion.

3.6. Quality Appraisal

The methodological quality of the 36 studies was evaluated using the Joanna Briggs Institute (JBI) critical appraisal checklists, which offer flexibility across diverse research designs. Each study was assessed for clarity of objectives, rigor of methodology, appropriateness of design, validity of measurement instruments, and transparency of reported findings. Based on this appraisal, 28 studies were classified as high quality, while 8 were judged to have moderate risks of bias, primarily due to small sample sizes, prototype-driven methods, or incomplete reporting. Disagreements in appraisal outcomes were resolved by consensus among the reviewers.

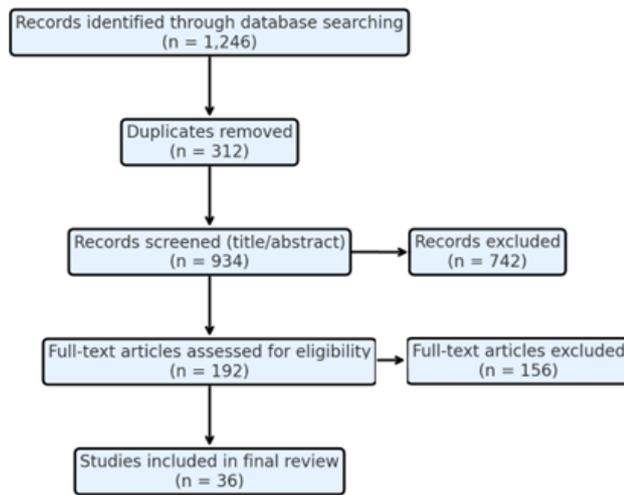


Fig. 1. PRISMA flow diagram

3.7. Data Synthesis

Given the heterogeneity of research designs, contexts, and outcomes, meta-analysis was not feasible. Instead, a narrative thematic synthesis was employed, drawing on the principles outlined by Thomas and Harden (2008). An inductive coding strategy was applied to the extracted findings, with each study coded line by line. Recurring concepts were grouped into higher-order categories, resulting in four overarching thematic domains: immersive visualization using VR and AR, adaptive design systems incorporating AI, smart multisensory environments, and sustainability and resource optimization. Within each thematic domain, findings were critically compared and contrasted, and contradictions, such as differences between technical performance outcomes and psychosocial benefits, were highlighted to emphasize gaps in knowledge and avenues for further research.

3.7.1. Rationale for synthesis approach

A quantitative meta-analysis was not feasible due to heterogeneity in research designs, outcome measures, and contexts across the included studies. The sample included not only experimental prototypes but also qualitative case studies, making it impossible to combine the results statistically. Given that the included studies employed diverse methods, a narrative thematic synthesis was adopted to preserve contextual details. This approach is among the most suitable for dealing with interdisciplinary data types. It allows researchers to identify the commonalities and differences without being compelled to drastically reduce the data.

3.7.2. Regional coding for cross-cultural insights

During data extraction, studies were coded by country and region to identify geographical trends. This process enabled the review to identify the uneven global distribution of research and evaluate the cross-cultural generalizability of the findings. As detailed in the Results section, the concentration of studies in Asia and Europe highlights the momentum of digital adoption in these regions and the underrepresentation of Africa and Latin America, which must be acknowledged as a scope limitation.

3.8. Transparency, Reliability, and Bias Mitigation

Several safeguards were incorporated to enhance the transparency and reliability of the review. Independent double-screening and data extraction reduced the risk of selection bias, while intercoder reliability was monitored during coding, with Cohen's kappa values exceeding 0.80, indicating strong agreement. The reasons for study exclusion at each stage were systematically documented. Potential sources of bias were acknowledged, including language bias from restricting to English-language publications and publication bias arising from excluding grey literature and non-peer-reviewed sources.

3.9. Ethical Considerations

As this study involved only the synthesis of previously published material, it did not involve human participants, animals, or sensitive data. Ethical approval and informed consent were therefore not required.

3.10. Comparative Insights across Technologies

A comparison of technologies revealed VR was the most extensively studied, showing more consistent positive outcomes for spatial cognition and communication, while AR remains less tested in real-world contexts. AI was primarily applied to sustainability optimization, but its implementation remains more conceptual than VR's. Smart environments occupied an intermediate position, offering promising user experience enhancements while facing barriers to cost and scalability. These comparative findings suggest that VR currently outperforms AR in applicability, while AI and smart systems remain in earlier stages of integration.

3. Results

The systematic search and screening yielded a final sample of 36 studies that met all eligibility criteria. The initial search across Scopus, Web of Science, IEEE Xplore, and ScienceDirect produced 1,246 records. After removing 312 duplicates, 934 records remained for screening by title and abstract. At this stage, 742 studies were excluded because they either did not focus on interior architecture or lacked a technological component. The full texts of 192 articles were retrieved for detailed evaluation, leading to the exclusion of 156 studies due to insufficient empirical data, methodological issues, or irrelevance to interior contexts. In the end, thirty-six studies met all inclusion criteria and formed the basis of this review.

The main characteristics of the 36 included studies, including methodological design, sample details, and technological focus, are summarized in Table 1.

Table 1. Study characteristics of the included articles (n = 36)

Attribute	Details
Publication Years	2018–2025
Geographical Distribution	Asia (15, 41.6%); Europe (11, 30.5%); North America (7, 19.4%); Middle East (3, 8.3%)
Journals	Architecture, Interior Design, Construction Engineering, Human–Computer Interaction
Study Types	Quantitative (15, 41.6%); Qualitative (12, 33.3%); Mixed Methods (9, 25%)
Samples/Participants	Design professionals, architecture students, end-users of smart environments
Technologies Studied	Virtual Reality (VR), Augmented Reality (AR), Artificial Intelligence (AI) tools, Smart Environmental Systems
Research Aims	Visualization and perception; User experience; Material/space optimization; Sustainability integration

The characteristics of the included studies reflect the interdisciplinary nature of technological research in interior architecture. All were published between 2018 and 2025, indicating a rapid acceleration of scholarly attention in recent years. Geographically, the largest proportion of studies originated from Asia (41.6 percent, n=15), followed by Europe (30.5 percent, n=11), North America (19.4 percent, n=7), and the Middle East (8.3 percent, n=3). This distribution underscores the concentration of scholarship in technologically advanced regions, while also revealing the relative scarcity of contributions from Africa and Latin America. Such an imbalance has implications for the global generalizability of findings, which must be considered when interpreting the results.

With respect to methodological approaches, fifteen studies (41.6 percent) adopted quantitative designs, most commonly controlled experiments and simulation-based evaluations. Twelve studies (33.3 percent) used qualitative methodologies, ranging from ethnographic case studies to in-depth interviews and design critiques. Nine studies (25 percent) employed mixed-methods frameworks, combining empirical testing with design-based inquiry. Collectively, the sample reveals a balanced representation of methodological strategies, though quantitative dominance suggests an emphasis on technical validation rather than long-term psychosocial outcomes. Participants included practicing designers, architecture students, and end-users, offering perspectives from both professional and educational contexts. The technological scope was equally diverse, encompassing virtual and augmented reality, AI-driven design platforms, and interactive environmental control systems.

The Joanna Briggs Institute checklists indicated that 28 studies (77.7%) met high methodological standards, demonstrating clearly stated objectives, appropriate designs, and transparent reporting. The remaining eight studies (22.3 percent) were assessed as having moderate risks of bias. The most common limitations were small sample sizes, absence of triangulation, and incomplete acknowledgment of study limitations. A notable proportion of prototype-based research further limited external validity, as systems were often tested in experimental settings rather than in full-scale implementation. While these weaknesses do not negate the significance of findings, they highlight a need for greater methodological rigor and longitudinal evaluation in future research.

The thematic synthesis of the thirty-six studies revealed four dominant clusters of findings. First, immersive visualization technologies such as VR and AR consistently enhance spatial perception, allowing designers, clients, and stakeholders to communicate more effectively. These tools reduced misinterpretation, increased design confidence, and supported collaborative decision-making. Importantly, while many studies confirmed these benefits, most were conducted in controlled environments or within educational contexts, raising questions about their scalability in professional practice. In practical terms, these findings suggest that VR, in particular, has the potential to reduce costly redesign cycles and improve client satisfaction when applied to real-world projects, even though such applications remain underexplored in large-scale industry trials.

The second theme addressed user experience and interactivity. Here, intelligent and flexible environments fulfill user needs through multisensory engagement across visual, auditory, and tactical domains. Therefore, the results indicate a transition in interior design from static layouts to dynamic, user-friendly environments. Nonetheless, these studies scarcely address the psychosocial and cultural aspects, leaving unanswered whether such systems foster social connection or contribute to isolation from a socio-psychological well-being perspective. Moreover, prototype-based research indicates that adaptive systems can positively impact user’s comfort. The functionality of offices, hospitals, and educational institutions could therefore be enhanced if cost and scalability issues are resolved.

The third group addressed sustainability and resource optimization supported by AI-focused design tools. These tools typically correlate with reduced quantities, material and energy consumption, and increased opportunities for adaptive reuse. However, despite promising findings, several factors inhibited the transition from prototype to practice, including high technical costs, institutional inertia, and a lack of supportive regulatory frameworks. This indicates a persistent research-practice gap that prevents the implementation of these innovations. While AI tools can demonstrate quantifiable benefits in resource reduction, without concrete examples validating their economic and logistical advantages, these benefits remain hypothetical for many organizations.

The fourth thematic area focused on educational and professional applications. Studies reported that VR-based learning platforms enhanced design comprehension, supported independent learning, and facilitated the acquisition of digital competencies among students. Such applications were also shown to prepare future professionals for increasingly digital design environments. While these outcomes are highly positive, the literature remains concentrated in academic settings, and evidence of systematic integration into professional training programs remains scarce. For the design industry, these findings imply that digital training environments bridge the gap between academic preparation and workplace requirements, though integrating them into formal professional training frameworks remains limited.

Table 2 provides an overview of these four clusters, mapping thematic domains with representative studies. Together, the findings reveal a field characterized by technological promise but constrained by issues of methodological heterogeneity, limited external validation, and regional concentration.

In summary, these results indicate that VR is the most mature and widely studied technology, demonstrating consistent positive impacts on perception and collaboration. By contrast, AR remains less validated and is underrepresented in real-world applications. AI has shown promise in sustainability optimization but remains largely conceptual, while smart environments occupy an intermediate position with strong experiential potential and unresolved cost and scalability concerns.

Table 2. Thematic synthesis of findings

Theme	Description	Representative Studies
Enhanced Visualization and Perception	VR and AR applications improved spatial understanding, reduced miscommunication, and strengthened client–designer collaboration.	Li et al. (2020); Wu and Han (2023)
User Experience and Interactivity	Smart and interactive systems enhanced multisensory engagement, personalization, comfort, and usability.	AlShkipi and Zahran (2024)
Sustainability and Resource Optimization	AI-based design tools optimized material selection, improved energy efficiency, and supported adaptive re-use of space.	Al Dwiek and Al Bast (2024)
Educational and Professional Applications	VR-based learning improved student comprehension and supported new digital skillsets among professionals.	Albayrak-Kutlay and Bengisu (2025)

4. Discussion

This systematic review shows that digital technologies, especially VR/AR and AI, are transforming interior architecture practices through advances in visualization, communication, sustainability, and professional training. The reviewed studies show a broad agreement that immersive technologies enhance spatial understanding and reduce miscommunication between designers and clients, thereby improving collaboration and decision-making. These results support earlier findings about the transformative power of interactive design and extend them by demonstrating measurable effects in both professional and educational settings (Albayrak-Kutlay and Bengisu, 2025; Xiang, 2025; Díaz González et al., 2025). Regarding sustainability, AI-based design platforms were found to optimize energy usage and material efficiency, aligning design choices with environmental goals and aiding the shift toward adaptive reuse and circular economy strategies (Rashdan, 2024; Al Dwiek and Al Bast, 2024).

These conclusions are consistent with a larger body of literature concerning digital transformation in design practices. Earlier studies pointed out that interactivity may enhance user engagement and decision-making in building systems (Li et al., 2020). This review affirms that these benefits do, in fact, translate into the interior sphere. Moreover, it appears that AI is beyond conceptual considerations and is being used systematically as a decision-support instrument to embed ecological approaches in the interior practice (Rashdan, 2016; Shams Al-Din, 2009). Nevertheless, divergences between perspectives also emerged in this review. For example, Wu and Han (2023) looked mostly into technical optimization and design efficiency, while Xiang (2025) and Burris (2014) pointed to psychosocial outcomes like creativity, comfort, and well-being. This divergence emphasizes that technological tools serve not only as technical enhancers but also become mediators of human experience, hence asking how cultural and contextual elements influence adoption.

Theoretically speaking, the findings from this research have been important for their theoretical implications. These findings support the interaction design principles (Rogers et al., 2011) by showing how some of the communication between the user and the environment for digital systems is structured, but also extend these principles to interior settings, characterized by adaptability and multisensory interaction. Furthermore, the review contributes to sustainability scholarship by linking AI-based optimization to ecological design frameworks and discussing digital technologies and their ability to operationalize sustainability theories in practice. From a technology adoption perspective, the findings align with models such as the Technology Acceptance Model and Human–Computer Interaction theory, which postulate perceived usefulness and usability as being the key determinants impacting adoption. By showing tangible effects on efficiency, collaboration,

and well-being, these studies lend empirical support to the theory while identifying barriers such as costs, regulations, and user skepticism, which continue to hinder adoption.

Also, practical implications are worthy of note. For professional practice, immersive visualization technologies such as virtual reality help limit costly redesign rounds by fostering a more exact collaboration of client and designer, while the AI-based platforms supply recommendations for evidence-based decisions with respect to material choice and resource management. VR training modules have all been shown to foster digital literacy and design understanding in educational settings, closing the gap between academic training and professional requirements (Díaz González et al., 2025). Hence, this establishes a foundation for embedding digital skills increasingly within curricula to prepare future designers for a rapidly evolving technological environment.

Notwithstanding these strengths, the review is not without limitations. Its comprehensive approach allowed for the integration of diverse perspectives, but several constraints shape the interpretation of findings. The reliance on English-language publications may have excluded valuable insights from non-English scholarship, introducing potential language bias. Furthermore, the concentration of studies in Asia and Europe, with minimal representation from Africa and Latin America, raises concerns about global generalizability. Methodological heterogeneity also complicated direct comparisons, as studies varied in design, scale, and outcome measures. Finally, the prevalence of prototype-based investigations, often tested in controlled or educational settings, limits the ability to draw firm conclusions about long-term adoption and scalability in professional practice.

These limitations point to several avenues for future research. First, while VR applications have been shown to enhance spatial perception and communication, there remains a lack of longitudinal studies evaluating their sustained effects on design quality, client satisfaction, and professional workflows. Second, although AI demonstrates considerable promise in optimizing sustainability, few studies have assessed its integration into adaptive reuse or circular economy frameworks, areas that are increasingly vital in contemporary environmental discourse (Rashdan, 2024). Third, the cultural dimension of digital adoption remains underexplored. Earlier studies on spatial identity and cultural traditions (Ayalp, 2012; Khudr and Ismail, 2015) indicate the importance of cultural mediation, yet most recent scholarship prioritizes technical efficiency over cultural context. Future research should therefore include cross-cultural and interdisciplinary investigations to better capture how digital systems interact with local practices, traditions, and values.

In summary, this review confirms that VR, AR, and AI technologies are significantly shaping the evolution of interior architecture by advancing visualization, enhancing the user experience, supporting sustainability, and enriching education. The evidence demonstrates both technical and psychosocial benefits, while also highlighting the limitations of current methodologies and the underrepresentation of diverse cultural contexts. By identifying these gaps, the study contributes not only to the consolidation of existing knowledge but also to the agenda for future inquiry into the digital transformation of interior design.

4.1. Practical and Policy Implications for Industry Adoption

While it is evident that VR, AR, AI, and smart systems could bring about a revolution in interior architecture, the presence of some practical barriers has currently limited their widespread use. Firstly, cost and scalability are the greatest challenges. The purchase of high-performance VR headsets, software platforms that are driven by AI, and environmental systems that are responsive requires financial investments that may limit small and medium design firms from adapting. Furthermore, these technologies will need to be maintained and updated, which will increase the long-term costs. As a result, most of the adoption is done in larger institutions or research-driven practices. Thus, smaller firms are left behind. Strategies such as phased implementation, shared technology labs, and cross-firm partnerships might help democratize access and lower the cost of entry.

Secondly, the extent to which these gadgets are integrated in conjunction with the training and digital literacy of practitioners presents a huge impediment. A considerable number of architects and designers are not entirely conversant with immersive platforms or AI-based design tools. Therefore, they create a skill gap that hinders the implementation.

Therefore, continuous professional development, specialized certification programs, and higher education courses that focus on digital skills as a learning outcome are urgently needed. Collaborative production between universities, the business sector, and professional organizations for members can be this close to closing the gap and also have a new generation of designers qualified with the skills required to make these tools produce powerful results.

Furthermore, the resistance of culture and organizations has been, and will always be, one of the great barriers to understanding adoption patterns. Just imagine the reaction of skepticism from designers and clients if they receive AI-based recommendations for the first time, and the ability is out of sight to produce outputs that reflect transparency, inventiveness, or cultural sensitivity when working with machine-generated recommendations. The confidence in only using prototype demonstration practice without fully considering the scalability issue is low. To calm down some of this fear, hybrid workflows can use AI and immersive tools not for replacement but for the augmentation of human creativity. Besides, the trust that comes from designing user-centered evaluative methodologies and the pilot projects in the field may be the reasons for the digital adoption to be tangible.

In the end, the regulatory and policy framework will have a very significant role as well. Moreover, sectors like land use, urban planning, and building codes, which have contributed to energy consumption and sustainability in the built environment, have almost never gone far enough to specify or promote the use of AI, assisted optimization, or immersive design visualization. For instance, a regulatory framework with technological advancement could be the main factor in

speeding up the process of execution through the addition of sustainability certifications that include criteria for the use of digital simulations. Moreover, the inclusion of digital design education in schools and accreditation systems would not only ensure that VR, AR, and AI skills become an integral part of the professional tools and offerings, but also make them simply one of the innovative possibilities. From a broader governance point of view, it stands out that policy implementation takes care of inclusion in access to digital infrastructure, the establishment of ethical guidelines for AI transparency, and the promotion of international cooperation on design technology standards are the necessary preconditions for advancing the translation of knowledge into inclusive and sustainable practice.

To summarize, bridging the gap in the implementation of technology is not a single step process. It requires a different approach that involves sectors such as industry, education, and policymaking. By linking advances to their real-life applications, the field of interior architecture will finally be able to move beyond experimental potential into the wider use of VR, AR, AI, and smart systems, and therefore make use of new technologies to revolutionize and recalibrate sustainable, human-centered design environments.

4.2. Conceptual Framework for Technology-Enabled Interior Architecture

This critique is new and unique because it delves into these topics not only with a systematic approach but also with a scope that considers the three historically disconnected areas of design, technology, and sustainability. Essentially, all the past reviews on the topic of the built environment have been quite similar in their treatment of these subjects. They have comprehensively engaged with VR, AI, or sustainability as separate ideas and have almost always stayed within architectural, computer science, or environmental studies disciplinary separation. By synthesizing the results from VR, AR, AI, and data, based optimization and smart environments, this review points out which ideas are at the intersection of both an applied and less expensive way, with a theoretical sense to further the interior architecture conversation. In this manner, the critique maps out to what extent immersive visualization, adaptive intelligence, and sustainability, the three latest innovations that have been treated separately, can co-exist as one integrated component, which is a group of interdependent drivers that can act in unison. It is this very integration that provides the potential for a theoretical framework of technology, enabling interior architecture that places digital systems as the common denominator between the human experience, ecological consideration, and innovative design.

The paper, therefore, aims to promote the use of digital tools that are minimally visible in the scene to only provide a new degree of attractiveness, but are still an essential part of a design thought that is from the sustainable world and human-centered. The concept demonstrates the distinctive feature of the present study that regards the manner of its impact on the existing research by reconciling the separate evidence into one unified, interdisciplinary design transformation across areas of a discipline.

5. Conclusion and Recommendations

This systematic review shows that digital technologies such as VR, AR, AI, and interactive systems are not marginal additions but transformative forces that enhance visualization, interactivity, and sustainability in interior architecture. Evidence confirms three trends: VR improves spatial perception and collaborative communication (Wu and Han, 2023; Xiang, 2025); AI enables energy efficiency and material optimization (Al Dwiek and Al Bast, 2024; Rashdan, 2024); and interactive systems support education and professional training (Díaz González et al., 2025; AlShkipi and Zahran, 2024). Together, these findings highlight how technology-integrated design thinking can enrich human experience while advancing environmental responsibility.

The review contributes by synthesizing insights across technology, environment, psychology, and education, moving beyond earlier works that treated cultural identity (Ayalp, 2012) or ecological awareness (Rashdan, 2016; Shams Al-Din, 2009) in isolation. It shows how VR and AI jointly reshape design theory and practice, extending discourse on innovation, sustainability, and well-being. In practice, immersive tools reduce redesign costs by improving client communication, while AI platforms strengthen sustainability by optimizing resource use. In education, VR bridges conceptual learning and professional application (Díaz González et al., 2025). Theoretically, the results reaffirm interaction design principles (Rogers et al., 2011) and demonstrate how digital tools operationalize sustainability in the built environment.

Limitations remain. language bias due to the exclusion of non-English studies, geographic imbalance favoring Asia and Europe, and reliance on prototypes with limited real-world validation. These highlight the need for more robust, cross-cultural, longitudinal evidence. Future research should expand beyond prototypes, integrate AI into adaptive reuse and circular economy frameworks (Rashdan, 2024), and examine cultural dimensions of digital adoption (Ayalp, 2012; Khudr and Ismail, 2015). Greater interdisciplinary collaboration across design, psychology, computer science, and engineering will be crucial for advancing theory and application.

From a policy and practice standpoint, researchers should refine integrated frameworks combining visualization, interactivity, sustainability, and education. Practitioners should embed immersive visualization and AI platforms into workflows to enhance communication and resource efficiency. Educators must update curricula to train students in VR and AI, while policymakers should promote ethical, sustainable adoption of these technologies.

In sum, VR and AI are reshaping interior architecture by advancing efficiency, sustainability, and user-centered design. By integrating technological, ecological, and cultural perspectives, digital tools not only transform material environments but also enrich the experiential and symbolic dimensions of interior spaces. This review provides scholars, practitioners, and policymakers with a roadmap for navigating the digital future of design where innovation and sustainability progress hand in hand.

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