COMPUTATIONAL RESEARCH PROGRESS IN APPLIED SCIENCE & ENGINEERING (CRPASE)

CRPASE: TRANSACTIONS OF CIVIL AND ENVIRONMENTAL ENGINEERING

Journal homepage: http://www.crpase.com

CRPASE: Transactions of Civil and Environmental Engineering 10 (2) Article ID: 2899, 1–12, June 2024 ISSN 2423-4591

Review Article

Exploring the Role of Building Information Modeling (BIM) and Virtual Reality (VR) Technologies in Interior Design: A Literature Review

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Keywords

Building Information Modeling (BIM), Virtual Reality (VR), Interior designs.

Abstract

As design and construction processes become more complicated, effective decision-making and smart data management become necessary. This paper explores the transformative impact of Building Information Modeling (BIM) and Virtual Reality (VR) technologies in interior design. BIM, serving as a digital representation of building characteristics, enhances collaboration and clash detection among design disciplines. At the same time, VR provides both designers and clients with immersive design experiences. Through a systematic literature review, this study highlights the increasing use of BIM and VR in interior design, emphasizing the development of design methods. VR has the potential to support human-centered design processes by enabling people to view places from various angles and in more detail. Moreover, BIM's role in centralizing project data and clash detection highlights the importance of improving design efficiency. Future research directions include delving into the details and interactivity of VR design experiences and enabling integration between the two technologies (BIM and VR) in interior design to provide immersive user experiences.

1. Introduction

The architecture, engineering, and construction (AEC) industry has become more complex in designing and constructing projects [1]; this implies that the designers' preferences don't just determine project modifications. This results from examining every piece of data to identify the most effective design. According to [1], professionals in the AEC sector use their knowledge to handle these and other construction-related tasks. This knowledge is essential for adapting to these challenges and emphasizes the importance of making well-informed decisions using contemporary construction techniques.

Furthermore, design and construction processes have been greatly enhanced by using information and data management systems in conjunction with building information modeling (BIM) [2]. This improvement sets a new standard in architectural performance compared to traditional methods used in the past. This means that BIM represents a transformative advancement in the industry. As noted by [3,4], the ease of recording and sharing information, including metadata and 3D geometry, using integrated BIM technologies surpasses traditional architectural documentation methods like elevation drawings and specifications. These authors argue that these capabilities demonstrate the advantages of BIM in streamlining workflows and enhancing communication among stakeholders.

BIM is a digital representation of a building or infrastructure's physical and functional characteristics and

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Received: 10 May 2024; Revised: 21 June 2024; Accepted: 29 June 2024
https://doi.org/10.61186/crpase.10.2.2899

Academic Editor: **Najmeh Bitaab**

Please cite this article as: I. Juba, Ö. Özeren, Exploring the Role of Building Information Modeling (BIM) and Virtual Reality (VR) Technologies in Interior Design: A Literature Review, Computational Research Progress in Applied Science & Engineering, CRPASE: Transactions of Civil and Environmental Engineering 10 (2024) 1–12, Article ID: 2899.

provides a comprehensive model by integrating various data sources [5]. BIM technology is often created as a management tools and repositories of digital construction documents [6], but it can also revolutionize the building design process and sustainability [7,8]. In a project's conceptual phase, BIM's benefit becomes most apparent. In the early stages, BIM plays an essential role in influencing the design process, promoting higher integration and providing more efficient feedback to form preliminary design decisions [9–11]. When BIM technologies are integrated with design, the design process becomes significantly more efficient [12,13]. The use of BIM extends to the construction phase and encompasses cost estimation, detailed modeling, and requirements. It involves developing new information procedures and integrating engineering services seamlessly. Collaborative design-construction integration, which allows for an accurate and unified approach throughout the project lifecycle, is a crucial component of this process [14,15].

The multifaceted interior design field involves applying mix technical and creative solutions inside buildings to produce finished interior environments. Developing and fostering human comfort in interior spaces using modern design methods such as using different types of glass [16] or colored glasses [17] to reduce solar transmittance and using thermal insulation material [18] can reduce reliance on active systems and lead to significant energy savings [16,19]. These solutions aim to be visually appealing, practical, and enhance people's quality of life and cultural experience. The designs consider the project's physical location and social context are designed according to the building's structure [20]. Therefore, the design must support environmental sustainability concepts [21–23] to give the user optimal interior experiences that achieve visual and thermal comfort. Research, analysis and the incorporation of knowledge into the creative process are all part of the systematic and organized interior design process. It ensures that the client's requirements and goals are fulfilled, leading to an interior area that meets the project's objectives [24].

Virtual reality (VR) in architecture is becoming more and more popular, and practitioners, researchers, and students find it increasingly interesting [25]. VR takes users into a realistic virtual environment by simulating a world that feels real to them. Essential components include the virtual environment, user-creator interaction, immersion, and interactivity [26]. VR presents innovative concepts that significantly go beyond traditional techniques when improving psychological perception and interior design decision-making. With its ability to create and experience spaces in new ways, VR technology is revolutionizing how customers and designers conceptualize living environments [27,28]. By offering a realistic and immersive environment, VR enables engineers to perceive and interact with the design in ways that traditional approaches cannot, aiding in the early identification and resolution of design issues [29].

Clients can see and explore an existing building in this way [30]. VR enables designers to develop 3D settings that clients can explore. VR is an excellent tool for working on and examining designs before they are built. With VR, designers and clients can navigate spaces, better understand the design, and decide on layout, materials, and furniture. It makes the design process more accurate and efficient by allowing designers to change things like lighting, colors, and furniture layouts in real time [31]. Recently, most studies have adopted VR technology in plant or building projects, with an emphasis on visualization, analysis and evaluation during the design and construction stages [32–42].

VR allows interior design to expand beyond the boundaries of physical space [27,28,43–46]. The use of VR devices enables in-depth involvement of individuals, leading to a higher level of satisfaction and understanding of complex furniture details through increased telepresence [47–51]. With the rapid advancement of VR technology, traditional architecture and interior design are experiencing a new development period.

Over time, progress has been made in VR applications and developments [52]. Recently, the integration of BIM and VR in architecture, engineering, and construction building projects has attracted attention as a promising advancement [53–55]. As interior designers, our goal is to be professionals who are knowledgeable, innovative, and capable of delivering quality work as part of project teams within the interior design industry and technology sectors. The interior design industry must consider combining skills and knowledge as critical to the design process. Currently, no specific BIM tools are tailored for interior design, and BIM is not typically used for generating exterior construction or structural systems. However, BIM can be beneficial during the design phase because it can effectively organize information and data. Additionally, it offers better visibility of the building's exterior and interior. Despite its benefits, BIM is not commonly used during the interior design stage. [24,56].

This research investigates the advantages of combining Building Information Modeling (BIM) and Virtual Reality (VR) technologies in interior design. The study explores how this powerful combination can transform interior design by highlighting the transformative potential of BIM and VR in producing more effective, immersive, and creative interior design solutions. It is also hoped to improve visualization, accuracy, efficiency, and stakeholder collaboration.

2. Research methodology

The purpose of this study was to provide a comprehensive evaluation of the literature, with an emphasis on the use of VR and BIM in interior design. This research provided insights into different methodologies and exciting discoveries that need further investigation in the fields of interior design, BIM, and VR technologies. It did this using a systematic review process that enabled an in-depth knowledge of the concepts explored in the analyzed articles.

Three major stages, all described below, were completed to achieve the goals:

1. Stage 1: involved establishing search criteria and keywords for the research, with Scopus selected as the primary database. The chosen keywords were ("interior design" OR "interior architect") AND ("BIM" OR "Building Information Modeling" OR "VR" OR "virtual reality").
2. Stage 2: Conducting article screening within the search series, encompassing research articles.

Duplicate articles were excluded; conference papers and proceeding documents were excluded from consideration; and non-English articles and those published without open access were excluded. The initial exploration of articles occurred in March 2024, identifying 228 articles from Scopus. After excluding non-English articles, the count was reduced to 224. Among these, only 72 were documented as articles. Based on accessibility, an additional 41 articles were excluded, leaving only those with open access. This process resulted in 31 articles for further qualitative analysis, as shown in Figure 1.

3. Stage 3: As outlined in Figure 1, a qualitative assessment was carried out on the 31 articles identified in the previous phase that met the inclusionary and exclusionary criteria specified in Table 1. The articles were expected to contain information about BIM tools and VR; furthermore, the research aimed to identify potential integration between this technology and interior design.

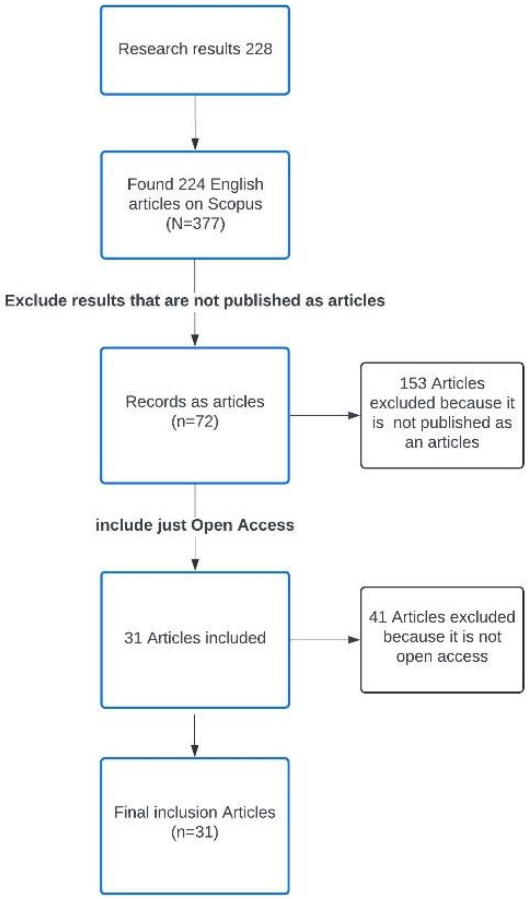

Figure 1. The flowchart diagram for articles for this review.

Table 1. Key Searching Criteria.

Key Criteria	
Inclusionary	Exclusionary
review articles that can be found on Scopus	Conference papers
Journal articles that can be found on Scopus	
Papers and Articles published in English	Non-English papers or articles
Articles and papers that are accessible and the full text in PDF are open source.	

3. Literature review

Full The systematic literature search utilized Scopus, and Figure 2 illustrates the publication trends from 2011 to 2024. In 2023, there were 55 publications, and by the end of March 2024, this number of publications had reached 22, with anticipated further growth.

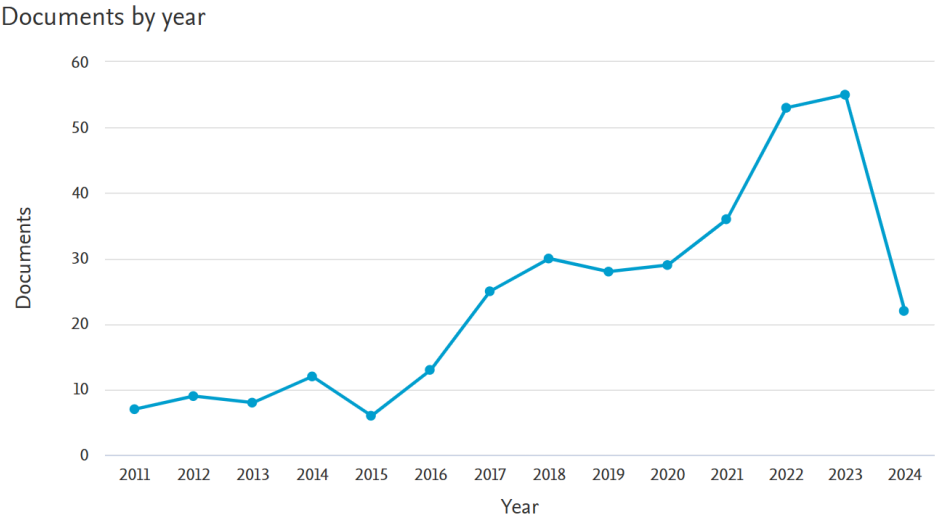

Figure 2. Document publications trends (Source: Scopus)

Documents connected to the VR and BIM fields originated from a singular origin and exhibited a variety of formats. Conference papers comprised the majority, representing 52.6% of all documents in the Scopus database, followed by articles at 35.7%, as shown in Figure 3.

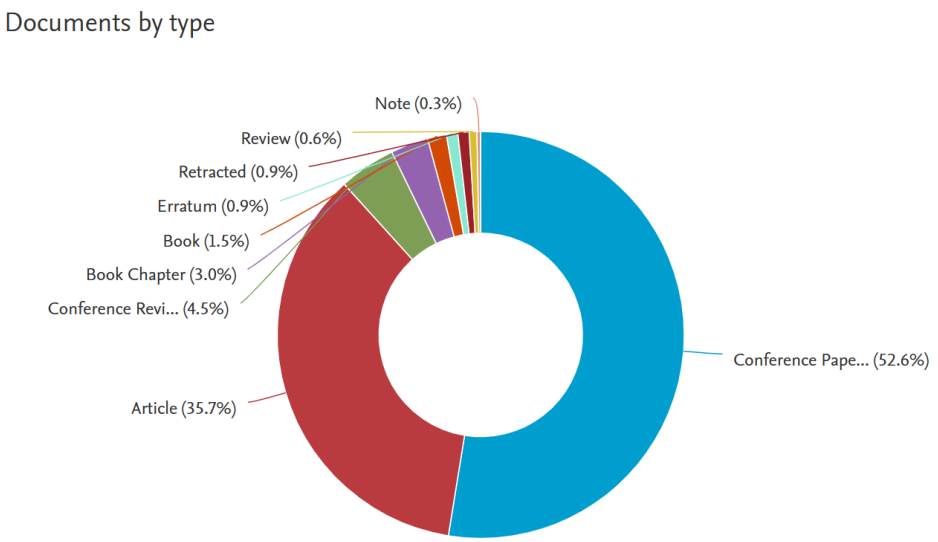

Figure 3. Document publications trends (Source: Scopus)

Furthermore, Scopus categorizes document publications by subject. It reveals that 27.5% of the subjects are associated with Computer Science, with Engineering at 25.1%, followed by Mathematics at 8.8%. Figure 4 presents a comparative overview of documents released by subject area.

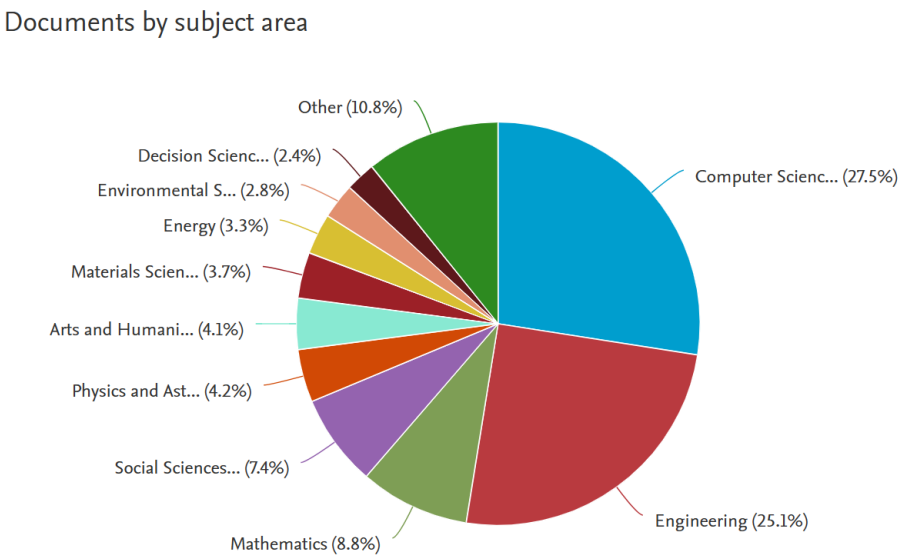

Figure 4. Subject-based comparison of document publications (Source: Scopus)

This part of the text examines research on how BIM can be used with VR to promote design in interior design processes. The information is based on a systematic literature review and is summarized in the following Table 2.

Table 2. A Summary of earlier research

Authors	Year	Findings	Method
Yu, Yeung, Tang, et al., (2011)	2011	The system generates lifelike indoor scenes with different furniture. The study checks if people notice a difference between the system's scenes and those made by human designers.	The system evaluates indoor furniture arrangements, considering visibility and accessibility, and refines the plan through simulated annealing with Metropolis-Hastings for layout optimization.
W.-C. Wang, (2013)	2013	Providing valuable insights for future digital furniture businesses and consumer-related studies by focusing on AR technology	Integration of Augmented Reality (AR) technology into the home furnishing experience.
Von Castell et al., (2014)	2014	How furniture can affect and change how we see a room's interior	In two tests showing how we see the inside of a room, one experiment used small model rooms with real furniture, while the other used VR.
Money et al., (2015)	2015	The study investigates how community-dwelling older adults perceive and utilize Computerized 3D Interior Design Applications (CIDAs) as tools to aid in home adaptations.	Ten participants engaged in interactive sessions with a customized Computerized 3D Interior Design Application (CIDA), followed by template analysis of both think-aloud and interview data.
Lee et al., (2017)	2017	They investigated how interior design elements affect prospective occupants' perceptions of amenity and efficiency in residential spaces.	Thirty-one participants employed VR environments featuring diverse interior designs to evaluate affordance, satisfaction, and perception processing regarding spatial design adequacy.
Rahmat et al., (2019)	2019	Collaboration VR for interior design enables customers and designers to work together from different locations.	The proposed collaborating VR application for real-time collaboration between customers and designers in interior design.
Ahmad et al., (2020)	2020	The study explores the adaptation of interior design education to VR in response to the COVID-19 pandemic.	The transformation from physical to virtual formats for teaching and presenting design projects by VR technology.
D'Amico et al., (2020)	2020	Integration workflow in the Building Information Modelling (BIM) process aims at monitoring and managing volatile organic compound (VOC) emissions from building materials to improve indoor air quality (IAQ).	Integration workflow in the BIM process involves systematizing IAQ parameters, integrating a numerical model for predicting VOC concentrations, and developing model checkers for performance verification.
Jolliff et al., (2020)	2020	Investigating how individuals with diabetes mellitus utilize home environment features to support Personal Health Information Management (PHIM).	Simulating home environments in a VR environment, where participants identified useful features for Personal Health Information Management (PHIM) tasks, with data analysis revealing insights into feature effectiveness

Nash et al., (2021)	2021	Using the virtual in interior design fosters a dynamic understanding of feelings that highlights the significance of lived experience and the connections between space and time.	The article explores VR design strategies to enhance embodied experiences and VR's potential to shape real-world behavior, especially fostering empathy.
H. Yang et al., (2022)	2022	Emphasizing the rising significance of green interior design while proposing a framework integrating immersive VR technology to optimize resource utilization and minimize environmental impact	Utilizing immersive VR technology to improve resource utilization efficiency mitigates negative impacts on human health and the environment in interior design.
L. Liu & Nhung, (2022)	2022	The study emphasizes the significant impact of VR and AR technology on various industries, particularly graphic design.	Involve analyzing the detailed application of VR/AR technology based on zSpace in graphic design.
M. Yang, (2022)	2022	VR technology offers significant advantages in interior design, surpassing other technologies in terms of interaction, immersion, and real-time capabilities.	The questionnaire aims to create a strong framework for integrating VR technology into interior design research to advance understanding and foster innovation in the field.
Nie, (2022)	2022	Utilization of 3D virtual technologies across industries for diverse spatial environments and immersive experiences in modern Chinese architecture	Experimenting with various VR technologies to evaluate their effectiveness in crafting immersive spatial environments, showcasing a multidisciplinary approach blending architecture, technology, and design
Pan et al., (2022)	2022	Integrating a BIM system has significantly enhanced the efficiency of architectural design. BIM merged design drawings from various areas, addressing inaccuracies and minimizing errors.	Researchers used BIM and Python programming for cross-platform collaboration, enabling deep learning and additional design tasks.
J. Zhang et al., (2022)	2022	Using VR to simulate different user perspectives (height and eye spacing) can improve a designer's empathy for the people who will use their designs.	The researchers developed a VR system enabling designers to experience diverse user perspectives, conducting experiments with 17 participants to perform design tasks.
T. Kim et al., (2022)	2022	The tool demonstrated its potential to facilitate lighting design in the workplace and enhance the creative process for designers.	Designing a VR-assisted lighting sketch tool, engaging six designers in workshops to generate 48 design outcomes.
Cho & Suh, (2023)	2023	Comparing individuals' performance on spatial reasoning tasks between VR and a conventional static paper-and-desktop environment	Thirty students participated in spatial ability assessments conducted in traditional paper, desktop and interactive VR environments, with their preferred learning styles and VR experience also being evaluated.
Ahmady et al., (2023)	2023	Investigating the impact of parametric interior roof design solutions on visitors' emotional and interactive spatial experiences in historical museums by VR	VR technology was employed to test parametric roof alternatives alongside the existing design, with 67 participants engaged with the VR simulations, providing quantitative feedback through questionnaires.
Tang et al., (2023)	2023	Emphasizes the use of digital marketing platforms with interactive VR features by interior designers to present their designs to clients in an engaging, user-friendly, and informative manner.	Conducting a web-based survey involving 120 participants to investigate their perceptions of digital marketing platforms for interior design
Kwon et al., (2023)	2023	Emphasizing a gap in research regarding using technology to design inclusive interior spaces tailored to the needs of individuals with neurodiversity	Integrating in-situ eye tracking and immersive virtual reality (IVR) technologies within the Participatory Neurodesign (PND) framework
Guo, (2023)	2023	Utilizing VR technology in interior design enhances user engagement and customization capabilities, offering a dynamic and immersive experience.	With the development of an interior design system based on VR technology, users gain access to virtual scenes and interactive functionalities.
D. Liu, (2023)	2023	Exploring the integration of VR technology in the development of virtual museums as a solution to the limitations of traditional museum infrastructure in China	Employing a comparative approach to assess the effectiveness of various technological advancements in enhancing the virtual museum experience
Yao & Qin, (2024)	2024	The VR-based interior decoration method is feasible and achieves a better virtual simulation effect on interior design, indicating its potential to revolutionize the interior design industry.	The research compares traditional interior design CAD schemes with VR-based methods, utilizing multiple project designs to evaluate efficiency and user satisfaction.
Y. Liu, (2024)	2024	CAD technology simplifies the design process, reducing costs and risks while improving response speed through optimized computing methods.	By utilizing CAD software, designers can efficiently conduct spatial planning, material selection, and rendering displays, leading to a better understanding of user needs.

Hong, Peng, et al., (2024)	2024	Integrating BIM technology with VR and AR enables the immersive experience of home perception.	Analyzing existing BIM applications in interior design and developing an intelligent algorithm using BIM+4D. Then, a survey was conducted to assess BIM technology's feasibility in this context.
Y. Zhang, (2024)	2024	Achieving virtual scene positioning and user perspective transformation in VR	Human spatial location mapping and field-of-view range techniques were used to position the virtual scene and manage the user's perspective within the VR environment.
Q. Wang, (2024)	2024	Showing high satisfaction with VR interior design fosters a more "human-oriented" design process that caters to individual needs and preferences.	Developed a VR interior design system that allows users to freely explore a virtual space, switch design elements, and personalize their experience.
Hong, Hu, et al., (2024)	2024	Investigating the impact of traditional symbols incorporated into VR interior design on the user experience in office spaces	Developing an index system to evaluate the integration level of traditional symbols in interior design
Doktah@mokhtar et al., (2024)	2024	The literature review on interior design in VR environments reveals VR's substantial potential as a tool for interior designers.	The systematic literature review rigorously examined studies on interior design in VR, initially screening 146 papers from Scopus databases and ultimately selecting six relevant papers for in-depth analysis.
Bettaieb et al., (2024)	2024	They explored how people perceive biophilic design (BD) elements in VR interior environments.	Ten families are experiencing VR-modified living rooms redesigned with biophilic design elements, followed by post-experience interviews to gather perceptions and feelings.

According to Table 2, there has been a noticeable rise in the number of research articles that have been published lately that address the integration of VR and BIM with interior design. This rise emphasizes how technology is becoming increasingly important and how closely interior design and design presentation techniques are related. Although most of the research examines the role of VR in interior design, it is impossible to minimize the value of BIM in developing interior design practices. The increasing number of research articles on BIM and VR in interior design highlights these technologies' important role in the industry. These are essential resources for contemporary interior designers because of their capacity to boost visualization, collaborate more effectively, and raise accuracy and productivity.

A repeated subject is the transformative potential of VR for interior design. For example, VR allows designers to create immersive, 3D environments where clients can virtually explore and experience the space before it is built, facilitating better design decisions and client satisfaction. e.g., [62,72,74,76,78,79,88] studies explore VR's ability to create immersive design experiences for designers and clients. This capability enhances visualizing key design elements such as color, material, lighting, volume, and scale. Accurate rendering of colors in a VR environment helps clients understand how different hues will interact within a space, affecting mood. Material simulations provide a tactile sense, allowing clients to perceive textures and finishes, which is crucial for making informed choices about flooring, furniture, and wall treatments. Volume and scale simulations in VR allow clients to experience the spatial proportions and flow of the interior, ensuring that spaces are neither too cramped nor too vast and that the furniture layout is practical and aesthetically pleasing.

According to Rahmat et al., and Cho & Suh, they talked about incorporating VR in interior design, which shows the strength and relationship between architects and customers by enabling immersive, user-oriented design experiences that allow clients to visualize and interact with the design from their perspective before construction begins [62,74]. It highlights a more "human-oriented" design process by allowing users to experience a design from their perspective before physical construction, e.g., [82]. Research suggests VR's effectiveness in concept visualization, particularly for public housing projects. VR enables designers to create more believable and human-focused places by simulating various user characteristics, such as height and eye spacing [70]. This feature is beneficial for ensuring that designs are accessible and meet the demands of all possible users. Additionally, L. Liu & Nhung, has emphasized the value of VR in concept visualization, especially for public housing projects where exact, lifelike simulations significantly impact design decisions [68].

VR has the potential to revolutionize interior design by providing new ways to explore and comprehend human experiences, spatial layouts, and design solutions. VR technology extends the limits of spatial perception through immersive experiences and interactive simulations, enhancing the design process and encouraging creative approaches to interior design. VR is integrated into many facets of interior design and spatial perception beyond design visualization. Ahmad et al., explores how VR transforms interior design education by providing students with immersive experiences that enhance their comprehension of intricate design ideas and spatial configurations [63]. VR enhances learners' awareness of interior spaces and design concepts by immersing them in virtual interior environments that promote discovering spatial relationships, lighting effects, and material interactions. Similarly, T. Kim et al., examine VR usage in digital marketing, focusing on how it may effectively engage consumers and communicate spatial concepts [73]. Designers may immerse potential customers in virtual interiors using interactive VR experiences, allowing them to engage and navigate with design aspects naturally and dynamically. Even in the medical field, research is needed to determine whether people with diabetes care for their health in a VR home setting, e.g., [64]. The capacity to produce realistic virtual environments with different furniture configurations, e.g., [88], provides

insightful information for upcoming digital furniture companies and customer behavior research, e.g., [88].

Another important technology that is having an impact on interior design is BIM. [72] emphasizes how BIM helps to provide a common information platform that unifies design disciplines and makes error correction and real-time collaboration possible. An immersive "home perception" experience is also made possible by integrating BIM with VR and AR, e.g., [82].

4. Discussion

A literature review shows an increasing trend in interior design toward integrating modern technologies like BIM and VR. It emphasizes how these technologies may revolutionize design visualization, customer participation, and collaborative workflows.

4.1 VR for Enhanced Visualization and Design Communication:

VR is an effective method for building realistic 3D settings, enabling clients to explore space even before construction virtually starts [74,78,79]. Research like Rahmat et al., and Tang et al., has shown that this capacity fosters improved client satisfaction and enables better-informed design selections [62,76]. Additionally, colors, material textures, lighting effects, and spatial proportions are essential design components that VR simulations help clients and designers visualize [62,74]. Stakeholders were able to make well-informed decisions about furniture placement, material choices, and general space functionality due to this immersive experience.

VR's capacity to promote a "human-oriented" design process is one especially significant facet of its influence on interior design [85]. VR simulations play a crucial role in user-centered design by enabling people to experience a design from their perspective, guaranteeing that environments are visually beautiful, beneficial, and functionally accessible [70].

4.2 VR for Expanding Spatial Perception and Design Innovation:

VR offers new opportunities for investigating spatial configurations, user experiences, design solutions, and aiding in design visualization. Because of its flexibility, it can simulate various user attributes and comprehend a range of user requirements [70].

Because of its versatility, VR benefits projects that impact the community, such as public housing construction, where realistic simulations can significantly affect design outcomes [68].

4.3 VR Applications Beyond Design Visualization:

VR impacts fields other than design, including marketing, education, and healthcare. VR is revolutionizing interior design education by providing students with immersive learning experiences that enhance their comprehension of intricate design principles [75].

VR is a powerful technology in marketing that can be used to communicate spatial concepts and engage potential customers efficiently [73]. Designers may effectively communicate their vision to clients and gain their buy-in by immersing users in interactive virtual environments.
VR also has uses in healthcare, such as helping to understand how people manage their health in virtual homes [64]. These simulations offer invaluable knowledge of human behavior and can guide the planning of medical facilities and environments that are supportive of one another.

4.4 The Rise of BIM in Interior Design:

Parallel to advances in VR technology, BIM integration is becoming more important for innovation in the interior design industry. BIM simplifies the design process and increases project productivity by establishing a central information platform for design disciplines that enables real-time collaboration and error correction [72].

Furthermore, By integrating smart home technologies, the "home perception" experiences in interior design are greatly improved through the integration of BIM and VR technology. Through the integration of BIM and 4D scheduling, designers may generate complex algorithms to effectively manage and forecast design timelines, resulting in the creation of interior home design templates and standards. Case studies show the possibilities and advantages of this integration, and survey data shows an average gain in spending on smart home features [82].

5. Conclusions

In conclusion, this study has thoroughly examined how VR and BIM are integrated into the interior design industry. This research sheds light on essential trends, methodologies, and discoveries in this developing field of study through a systematic literature review.

According to the data, there has been a noticeable increase in research articles on BIM and VR in interior design, highlighting the expanding influence of technology on design processes and presentation techniques. VR is becoming an effective tool for improving visualization, encouraging client involvement, and fostering creative design solutions. Research has demonstrated how VR can produce attractive 3D settings, help with decision-making during the design process, and encourage a more "human-oriented" approach. VR is also helpful in marketing, healthcare, and education, going beyond design visualization. Because of its flexibility, it is particularly beneficial in the design process.

Along with the development of VR, BIM integration has emerged as an important engine behind interior design innovation. BIM improves project efficiency and speeds up the design process by establishing a common information platform and permitting real-time collaboration. BIM offers stakeholders a holistic understanding of spatial layouts and design concepts when integrated with VR technologies.

Overall, the findings of this study underscore the transformative potential of BIM and VR technologies in interior design. These technologies enhance visualization and communication and foster creativity, collaboration, and

user-centered design approaches. As technology develops, further research and exploration in this area will lead to continued advancements and innovations in interior design practices.

6. Recommendations

Moving forward, several recommendations and avenues for future research come from this study:

1. Integration of interior design using BIM technology and VR technology: From previous studies, it can be concluded that these technologies were used separately, with VR being the most common in interior design, and BIM technology having little presence in this field. Few studies have discussed regarding interior design using BIM technology. It indicates the lack of use of this technology in this field despite its great benefits.
2. Going into more detail on user experience in VR environments: Future research could delve deeper into understanding user experiences within interactive VR environments, particularly focusing on design options and different material options such as color schemes, lighting effects, and material textures. Future research could also investigate how these factors impact user perceptions and preferences, including the sound system.
3. Integration of Augmented Reality (AR) and Mixed Reality (MR): While this study primarily focused on VR technology, future research could explore the integration of AR and MR technologies in interior design. AR and MR offer unique opportunities for overlay digital information onto physical spaces, enhancing spatial understanding and interaction. Investigating the potential applications of AR and MR in interior design could uncover new design possibilities and enhance user experiences.
4. Cross-disciplinary Collaboration: Encouraging collaboration between interior designers, architects, technologists, psychologists, and other relevant disciplines could foster innovation and creativity in VR and BIM applications. By bringing together diverse expertise, researchers can develop holistic approaches to address design challenges and maximizing the potential of emerging technologies.

Overall, future studies in this area should aim to deepen our understanding of the potential of VR and BIM technologies in interior design, connect these two technologies within this field, and address the associated challenges.

Acknowledgments

This article is part of a master's thesis by Ibrahim Juba that investigates "The integration of building information modeling (BIM) and Virtual Reality (VR) to enhance interior design processes." supervised by Assoc. Prof. Dr. Ömer Özeren, submitted to Karabük University in 2024-2025.

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