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The Impact of Biophilic Design on Virtual Reality Learning Environments: A Narrative Review

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Abstract

Biophilic design is recognized for improving well-being, cognitive performance, and learning outcomes in educational spaces. However, its potential within immersive learning environments remains underexplored. This study aims to investigate how integrating biophilic principles in the design of Virtual Reality environments can influence learning experiences and performance. The paper presents a narrative literature review on the use of biophilic design in VR learning environments, analysing studies from major academic databases to identify key themes, design strategies, and outcomes related to biophilic elements in digital spaces. Findings indicate that incorporating natural patterns, daylight simulation, vegetation, and biomorphic forms in VR environments may support attention restoration, reduce cognitive fatigue, and enhance learners' sense of presence and emotional comfort. These results highlight the potential of biophilic VR design as a strategy to support healthier and more effective immersive learning environments, contributing to emerging research at the intersection of architecture, digital environments, and educational design.
Keywords: Biophilic design; Virtual Reality; Immersive learning environments; Spatial design; Educational spaces.

1. Introduction

Biophilic design has become an increasingly relevant approach in architecture and environmental design due to its potential to reconnect human-made spaces with natural systems, processes, and forms. The concept is rooted in the biophilia hypothesis, which suggests that human beings have an innate tendency to affiliate with life and life-like processes (Wilson, 1984). In architectural terms, this idea has been translated into design strategies that integrate nature into the built environment through direct experiences of nature, indirect references to nature, and spatial qualities that evoke natural settings (Kellert, 2018). These strategies include the use of daylight, vegetation, natural materials, water, views to nature, organic forms, biomorphic patterns, prospect and refuge, spatial complexity, and multisensory environmental cues. The importance of biophilic design is supported by several theoretical frameworks in environmental psychology and evidence-based design. Attention Restoration Theory argues that natural environments can support recovery from directed attention fatigue by offering experiences of fascination, being away, extent, and compatibility (Kaplan, 1995). Stress Recovery Theory similarly suggests that exposure to natural environments can produce positive affective and physiological responses, reducing stress and supporting emotional regulation (Ulrich, 1984). These theories have strongly influenced research on restorative environments and have contributed to the growing interest in designing buildings that actively support health, comfort, and cognitive performance.

Educational environments are particularly relevant to this discussion. Schools, universities, classrooms, studios, corridors, and informal learning spaces are not neutral containers for instruction; they shape attention, motivation, social interaction, emotional comfort, and cognitive performance (Li & Sullivan, 2016; Peters & D'Penna, 2020). Students often spend long periods in indoor environments that may be visually monotonous, cognitively demanding, and disconnected from natural stimuli. In this context, biophilic design offers a framework for rethinking learning spaces as environments that support both educational activity and psychological well-being. Previous studies on physical educational spaces have associated natural light, greenery, window views, natural materials, and spatial comfort with improved satisfaction, attention, perceived restoration, and learning-related experiences (Barbiero et al., 2025).

At the same time, education is increasingly mediated by digital and immersive technologies. Virtual reality (VR) has become an important tool in educational research and practice because it enables immersive, interactive, and spatially rich learning experiences. Unlike conventional digital media, VR allows users to experience scale, depth, movement, and presence within simulated environments. For this reason, VR is increasingly used not only to deliver educational content but also to simulate architectural spaces, test design alternatives, and evaluate user responses under controlled conditions.

In learning contexts, presence and immersion are often considered central to engagement, motivation, and experiential understanding (Mollazadeh & Zhu, 2021; Di Giuseppe et al., 2024).

However, the growing use of VR in education raises an important architectural question: how should virtual learning environments be designed? Many VR learning applications focus primarily on content, interaction, or technological performance, while the spatial and environmental qualities of the virtual setting are often treated as secondary. Yet, if VR environments are experienced spatially, they should also be designed spatially. This means that principles traditionally applied to physical architecture, such as visual comfort, atmosphere, materiality, lighting, spatial organization, and environmental quality, may also be relevant in immersive digital spaces. This issue is especially important because VR learning environments can also produce cognitive and physiological challenges. Immersive environments may increase attention and engagement (Brylska et al., 2024; Radianti et al., 2020), but they can also contribute to cognitive overload, visual fatigue, disorientation, discomfort, and stress if they are poorly designed (Makransky et al., 2019; Parong & Mayer, 2021). As a result, the design of VR learning environments should not be limited to realism or technological novelty. It should also consider how virtual spaces affect learners' emotional states, cognitive load, attentional resources, and sense of comfort. Biophilic design may offer a promising strategy in this regard, because it provides spatial and environmental principles aimed at supporting restoration, well-being, and human-centered experience. Recent studies on virtual nature suggest that simulated natural environments can produce psychological and psychophysiological benefits, including improved mood, reduced stress, and perceived restoration (Mostajeran et al., 2023; Sella et al., 2025). These findings indicate that nature-related experiences do not necessarily require direct physical exposure to natural settings, although real nature and virtual nature may differ in intensity and quality of effect. VR can therefore serve two complementary roles: it can act as a research tool for testing environmental design variables, and it can also become a design medium through which restorative and biophilic experiences are created. Within this emerging field, biophilic design in VR learning environments remains underexplored. Existing research on biophilic design has largely focused on physical settings such as hospitals, offices, schools, campuses, and urban environments, whereas research on VR in education has instead mainly examined learning outcomes, presence, engagement, and usability. Fewer studies have explicitly investigated how biophilic principles can be integrated into VR educational spaces and how such integration may influence attention, stress, satisfaction, cognitive comfort, emotional well-being, or perceived restoration.

Therefore, to address the emerging intersection between architectural design, education, and immersive technologies, this review study aims to investigate how biophilic design has been addressed in the literature on virtual reality learning environments and to synthesize the main design strategies, outcomes, and implications emerging from the available studies. Specifically, the review seeks to answer the following Research Questions (RQs):
RQ1: *How has biophilic design been integrated into virtual reality or digitally simulated learning environments?*
RQ2: *Which direct and indirect biophilic elements are most commonly examined in these environments?*
RQ3: *What cognitive, emotional, physiological, and experiential outcomes are associated with biophilic VR learning environments?*
RQ4: *What design implications can be derived for architects, educators, and designers of immersive educational spaces?*

By addressing these questions, the paper contributes to the growing discussion on how architecture can engage with virtual and hybrid learning environments. The review also highlights the need for more empirical research and evidence-based guidelines to support the design of immersive educational spaces that are not only technologically effective but also restorative, comfortable, and cognitively supportive.

2. Materials and Methods

This study adopts a narrative review approach (Paré et al., 2015) supported by a structured literature search. A narrative review was considered appropriate because the topic is emerging, interdisciplinary, and characterized by a limited number of directly relevant studies. The review does not aim to provide a meta-analysis or a full systematic review, but rather to identify, interpret, and synthesize the main research themes, design strategies, and reported outcomes at the intersection of biophilic design, virtual reality, and learning environments.

The literature search was conducted using two major academic databases: Scopus and Web of Science. The search was performed using terms related to biophilic design, virtual reality, education, and learning environments. The search string was formulated as follows:

«TITLE-ABS-KEY ((biophilic design) AND (VR OR Virtual Reality) AND (learning OR education) AND (environments))».

The initial search returned 69 records. These records were screened by title, abstract, and keywords to assess their relevance to the scope of the review. The screening process aimed to identify studies that explicitly connected biophilic design or nature-based spatial strategies with virtual reality, immersive simulation, or digital learning environments.

Studies were included when they met the following criteria: (1) they explicitly addressed biophilic design, biomorphic design, nature-based design, or nature-inspired spatial features; (2) they involved virtual reality, immersive simulation, virtual 3D environments, or technologically mediated spatial representation; (3) they focused on learning, education, school, university, classroom, studio, or kindergarten environments; and (4) they reported design strategies, cognitive outcomes, emotional responses, physiological indicators, student satisfaction, perceived restorativeness, or educational implications. In contrast, studies were excluded if they focused exclusively on physical environments without any virtual or technology-mediated component, discussed biophilic design without educational relevance, addressed virtual reality without reference to environmental or spatial design, or focused on general sustainability rather than biophilic or nature-based design principles.

Following the screening process, five studies were selected for inclusion in the narrative synthesis. The final corpus included experimental VR studies, VR-based design evaluations, virtual 3D simulations, and one qualitative design-oriented study. Although the included studies differ in methodological approach, all were considered relevant because they contribute to understanding how biophilic and nature-inspired design strategies may be applied to immersive or technologically mediated educational environments.

3. Results

3.1 Overview of Included Studies

The five included studies covered diverse educational settings and methodological approaches, as detailed in **Table 1**. Binarti et al. (2025) examined university classroom window views using VR simulations and EEG-based neurophysiological measurements. Kang et al. (2026) investigated biomorphic and ecological surface finishes in a VR-based educational environment using EEG and psychological measures. Mahrous et al. (2024) used VR simulation to evaluate the impact of biophilic attributes on university students' satisfaction in a design studio. Mengqi et al. (2025) used virtual 3D models to assess the protective and restorative effects of biophilic forms in high school classrooms and corridors through physiological and cognitive measures. Khalid Hassan and Al-Alwan (2025) adopted a qualitative literature and case study approach to examine how biophilic and technological design strategies can enhance kindergarten architecture.

Table 1: Summary of the studies included in the narrative review.

Study	Educational context	VR / digital method	Biophilic or nature-inspired elements	Sample	Measures	Main findings	Relevance to the review
Binarti et al. (2025)	University classroom in a green campus setting	VR-simulated classroom conditions with different window orientations and outdoor views	Forest view, park view, city view, visual access to greenery, classroom window views	10 architecture students	EEG using a 14-channel Emotiv EPOC X headset; analysis of delta, theta, alpha, beta, and gamma frequency bands	Forest views produced the most restorative neural responses, with increased alpha and theta activity and reduced beta and gamma power. City views were associated with cognitive load and overstimulation, while park views supported balanced attentional engagement.	Provides evidence that simulated natural views in VR classrooms can influence neurophysiological states related to restoration, attention, and cognitive load.
Kang et al. (2026)	University lecture-room / educational virtual environment	VR-based classroom with controlled manipulation of interior surface finishes	Natural wood finish, biomorphic cellular geometry, textile pattern, neutral reference condition	30 participants	EEG alpha power; PANAS; IPQ; spatial assessment	Wood and biomorphic cellular finishes produced significantly higher occipital alpha activity than reference and textile conditions. These finishes were associated with visual comfort, reduced mental effort, emotional relaxation, higher comfort and interest, and lower nervousness.	Shows that biophilic effects in VR learning environments can be produced not only through vegetation or views, but also through ecological materiality and biomorphic geometry.
Mahrous et al. (2024)	University design studio at the British University in Egypt	VR simulation comparing existing studio conditions with a biophilic redesign	Natural lighting, natural ventilation, greenery, large windows, indirect connection to nature, natural finishing materials	52 architecture students	Satisfaction assessment; Perceived Restorativeness Scale; cognitive/performance assessments; statistical analysis using SPSS	Biophilic design attributes had a positive impact on students' satisfaction and perceived restorativeness. Natural lighting, natural ventilation, greenery, large windows, indirect connection to nature, and natural finishing materials were among the most relevant attributes.	Links VR-based architectural simulation with students' satisfaction and perceived restoration in a university learning environment.
Mengqi et al. (2025)	High school classrooms and corridors in China	Virtual 3D models comparing non-biophilic, curved biophilic, and biomimicry	Curved forms, biomimicry forms, waterdrop shapes, branches, flowers, leaves,	96 high school students	Skin conductance level, heart rate, HRV indicators, creativity tests, attention tests,	Curved biophilic forms facilitated greater cognitive improvement and stress reduction. Non-biophilic forms showed stronger stress-protection effects, suggesting that different design	Highlights the need for activity-sensitive biophilic VR design and shows that biophilic elements may support relaxation,

		design conditions	organic geometry, indirect experience of nature		subjective assessments	conditions may be suitable for different learning activities.	creativity, and attention, but may not be universally optimal for every learning task.
Khalid Hassan & Al-Alwan (2025)	Kindergarten architecture and early childhood learning environments	Qualitative literature synthesis and documented case-study analysis; technological approaches include interactive walls, augmented reality, and virtual reality	Natural light, plants, water, organic materials, outdoor learning, flexible multisensory environments, interactive technology, AR/VR	Not applicable	Qualitative synthesis; case-study analysis; development of design strategies	The study proposes five design strategies: integrating learning environments with nature, integrating interactive technology, supporting diverse learning styles, creating flexible multisensory environments, and enhancing health and well-being.	Useful for architectural implications and design strategies, especially for connecting biophilic design, technology, multisensory learning, and child-centered educational environments.

3.2 Biophilic Elements Identified In VR Learning Environments

The included studies show that biophilic design in virtual learning environments can be implemented through both direct and indirect references to nature.

Direct biophilic elements included natural views, greenery, daylight, natural ventilation, large windows, and natural materials. In Binarti et al. (2025), the key biophilic variable was the visual connection to natural outdoor environments via simulated classroom window views. Forest, park, and city views were compared to assess their effects on students' EEG responses. The results indicated that the type and quality of view were more influential than window orientation, with forest views producing the strongest restorative patterns. Mahrous et al. (2024) identified a broader set of biophilic attributes in a university design studio, including natural lighting, natural ventilation, greenery, large windows, indirect connection to nature, and natural finishing materials. These attributes were tested through VR simulation and were positively associated with students' satisfaction and perceived restorativeness.

Indirect biophilic elements were also prominent. Kang et al. (2026) examined ecological surface finishes, including wood and biomorphic cellular geometry. Their study is particularly relevant because it shows that biophilic design in VR does not need to rely only on vegetation or outdoor views; it can also operate through materiality, texture, geometry, and pattern. The wood finish represented natural materiality, while the biomorphic cellular pattern was derived from biological structures such as leaf venation and coral-like geometries. Mengqi et al. (2025) focused on indirect contact with nature through curved and biomimetic forms. Their design prototypes included natural forms such as water droplets, branches, flowers, leaves, circular and elliptical forms, arches, undulating lines, and dynamic patterns inspired by plant and animal contours. The study explicitly addressed the lack of empirical evidence on indirect biophilic forms in school environments. The implications of Hassan and Al-Alwan (2025) are useful in this regard. Finally, the study by Khalid Hassan and Al-Alwan (2025), although not experimental, emphasizes the need to integrate biophilic and technological approaches into early educational environments. Their proposed strategies, including connecting learning environments with nature, integrating interactive technologies, supporting diverse learning styles, creating flexible multisensory spaces, and enhancing health and well-being, are relevant for the broader design of immersive learning environments.

3.3 Reported Effects on Attention, Restoration, and Cognitive Comfort

In all studies, VR served as a controlled platform for architectural experimentation: rather than treating VR solely as an educational technology, the studies used it as a design-research method to isolate spatial and environmental variables. The most frequent outcomes across the four studies that adopted objective measures were not conventional academic grades but attention, restoration, cognitive comfort, satisfaction, stress reduction, emotional stability, creativity, and perceived restorativeness. Binarti et al. (2025) found that forest views promoted restorative neural states characterized by increased alpha and theta activity and reduced beta and gamma power. City views produced neural patterns associated with cognitive load and overstimulation, while park views supported balanced attentional engagement. This finding is important because it suggests that VR-simulated natural views can influence neurophysiological states associated with attention restoration and visual rest. Kang et al. (2026) reported that wood and biomorphic cellular finishes produced significantly higher occipital alpha activity than reference and textile conditions. The wood and cell finishes generated mean alpha increases of 16.6% and 14.9%, respectively. The authors interpret elevated alpha activity as a neural indicator of visual comfort, reduced mental effort, and emotional relaxation. Complementary psychological results also showed higher comfort and interest and lower nervousness under the wood and cellular conditions. Mahrous et al. (2024) found that natural lighting, natural ventilation, greenery, large windows, indirect connection to nature, and natural finishing materials were strongly and positively associated with students' satisfaction and perceived restorativeness in a VR-tested university design studio. The study also suggests that students' satisfaction can be considered a relevant outcome when assessing the quality of learning environments, particularly in architecture and design education. Mengqi et al. (2025) showed that indirect exposure to nature, particularly curved forms, facilitated greater cognitive improvement and stress reduction. However, their study also found that non-biophilic forms offered stronger stress-protection effects. This led the authors to suggest that non-biophilic environments may be better suited to stress-inducing tasks such as classes and examinations, whereas curved biophilic environments may be better suited to relaxation, creativity, and attention. Although Khalid Hassan and Al-Alwan (2025) did not report primary experimental measurements, their qualitative synthesis and case-study analysis suggest that integrating biophilic and technological approaches in kindergarten architecture may support children's psychological balance, attention, sensory engagement, social interaction, and cognitive, motor, and linguistic development; their contribution is therefore mainly design-oriented.

3.5 Emerging design strategies

The findings point to several emerging design strategies for biophilic VR learning environments. First, natural views appear to be particularly important. Forest-like greenery produced the strongest restorative EEG responses in Binarti et al. (2025), while park views supported a more balanced state between restoration and attentional engagement. This suggests that dense greenery and visual access to nature should be prioritized where the design goal is attention recovery or mental fatigue reduction. Second, biophilic effects may also be produced through materiality and geometry. Kang et al. (2026) showed that wood and biomorphic cellular finishes increased alpha activity and positive affect, whereas textile patterns did not differ significantly from the reference condition. This suggests that visual complexity alone is insufficient; biophilic features should convey ecological or biomorphic relevance. Third, architectural attributes traditionally associated with physical learning spaces remain relevant in VR-based design evaluation. Mahrous et al. (2024) found that natural lighting, natural ventilation, greenery, large windows, indirect connection to nature, and natural finishing materials were positively associated with students' satisfaction and perceived restorativeness in a VR-simulated design studio. Fourth, biophilic design should be calibrated according to the learning activity. Mengqi et al. (2025) showed that curved biophilic forms supported stress reduction, attention, and creativity, while non-biophilic settings offered stronger stress-protection effects, suggesting that different spatial atmospheres may be appropriate for different pedagogical tasks. Finally, Khalid Hassan and Al-Alwan (2025) extend these findings from experimental outcomes to design implications, emphasizing flexible, multisensory, and technology-enhanced learning environments that integrate nature, interactive tools, and child-centered spatial strategies.

4. Discussion

This narrative review highlights an emerging but still fragmented research area at the intersection of biophilic design, virtual reality, and learning environments. The limited number of studies included in the review suggests that, despite the growing relevance of both biophilic design and immersive educational technologies, their integration remains underdeveloped. This gap is significant for architectural research because VR learning environments are increasingly experienced as spatial environments, yet they are often designed primarily from technological, pedagogical, or interaction-based perspectives. The findings of this review suggest that their environmental and architectural qualities deserve greater attention.

A key implication emerging from the reviewed literature is that biophilic design in VR should not be interpreted as the mere visual addition of natural elements to a digital scene. Rather, it should be understood as a broader spatial and environmental strategy. In physical architecture, biophilic design operates through light, materiality, form, view, spatial organization, sensory variation, and atmosphere. The same logic appears relevant in immersive environments. This means that the translation of biophilic design into VR should move beyond the simple representation of greenery or landscapes and address how natural references structure perception, attention, comfort, and emotional response within the virtual space. This distinction is particularly important because VR environments can easily produce visually rich but cognitively demanding spaces. In this sense, biophilic design should not be confused with complexity, decoration, or aesthetic naturalism. The reviewed studies indicate that the restorative potential of biophilic elements depends on their ecological coherence, perceptual legibility, and relationship to the learning task. A virtual environment may include natural textures, organic geometries, or green views, but these features are unlikely to be effective when applied as superficial visual layers. For biophilic VR learning environments, the design challenge is therefore not to maximize the amount of nature-like imagery, but to calibrate environmental stimuli in ways that support specific cognitive and affective states. This point leads to a second critical issue: biophilic design should not be assumed to be universally beneficial. The evidence reviewed suggests that different learning activities may require different environmental conditions. Spaces intended for restoration, creativity, informal learning, or reflection may benefit from stronger biophilic qualities, while tasks requiring high focus, performance pressure, or low distraction may require more neutral spatial conditions. This challenges a common tendency in biophilic design discourse to frame nature-based interventions as inherently positive. In immersive learning environments, the effectiveness of biophilic design is likely to depend on the type of task, exposure duration, user characteristics, and the intensity of sensory stimulation. The review also points to a conceptual shift in how VR learning environments should be understood. Many educational VR applications are designed around content delivery, simulation accuracy, or user interaction. While these dimensions are essential, they do not fully address the spatial experience of learning. If users inhabit VR environments through embodied perception, then these environments should be considered architectural spaces rather than neutral digital containers. From this perspective, architecture can contribute to VR education by bringing expertise in spatial atmosphere, environmental psychology, material perception, visual comfort, and human-centered design. Another important implication concerns the methodological role of VR in architectural research. VR is not only a medium for immersive learning; it is also a controlled experimental platform for testing design hypotheses. This is especially valuable for biophilic design, where isolating the effects of specific environmental variables in real buildings is often difficult. Virtual simulations enable comparison of alternative views, materials, geometries, and spatial configurations while controlling external factors. However, this methodological advantage also raises questions about ecological validity. Responses to simulated environments may not fully correspond to responses in physical spaces, particularly when multisensory cues such as smell, air movement, temperature, tactility, and acoustic complexity are absent or simplified.

The reviewed literature also reflects a broader movement toward evidence-based and neuroarchitectural approaches to design. The use of physiological and neurophysiological measures offers promising ways to assess how environments influence stress, attention, and cognitive effort. However, these measures should be interpreted cautiously. Indicators such as EEG alpha activity, heart rate variability, or skin conductance can provide useful insights, but they do not directly translate into educational effectiveness. Similarly, satisfaction or perceived restorativeness cannot be equated with learning performance. The current evidence, therefore, supports a more modest claim: biophilic VR design may create environmental conditions that are favorable to learning, but it does not yet demonstrate consistent improvements in academic outcomes. This distinction is crucial for positioning the contribution of the present review. The value of biophilic design in VR learning environments should not be reduced to whether it directly improves test scores. Learning is influenced by a broader ecology of factors, including attention, motivation, stress, comfort, engagement, and emotional safety. Biophilic design may contribute to this ecology by regulating the environmental conditions under which learning takes place. In this sense, its contribution is indirect but potentially meaningful: it may support the cognitive and emotional prerequisites for effective learning. The inclusion of studies across different educational levels also suggests that biophilic VR design cannot be addressed through a single universal model. University classrooms, design studios, high school corridors, and kindergarten environments involve different users, pedagogical goals, behavioral patterns, and developmental needs. For younger learners, multisensory engagement, movement, play, and emotional security may be central. For university students, visual comfort, cognitive recovery, concentration, and creative engagement may be more relevant. Future design frameworks should therefore be age-sensitive and pedagogically specific rather than generic. The review also reveals an unresolved tension between standardization and personalization. On the one hand, evidence-based design requires generalizable principles that can guide practice. On the other hand, VR environments are highly adaptable and could allow more personalized environmental conditions than physical classrooms. This raises an important future direction: biophilic VR learning environments could be dynamically adjusted according to task, learner state, or pedagogical objective. For example, a virtual space might shift from a low-stimulation setting during assessment to a more restorative or exploratory atmosphere during creative work. Such adaptive environments would extend biophilic design from static spatial composition to responsive environmental regulation.

Despite its potential, the field remains limited by methodological heterogeneity and a small evidence base. The included studies differ in sample size, educational context, VR setup, design variables, exposure duration, and outcome measures. This makes direct comparison difficult and prevents strong conclusions about which biophilic elements are most effective. Moreover, most studies examine short-term responses, while the long-term effects of repeated exposure to biophilic VR environments remain unknown. There is also limited evidence on possible negative effects, such as distraction, overstimulation, novelty bias, visual fatigue, or cybersickness. Future research should therefore adopt more rigorous comparative designs, larger and more diverse samples, and clearer distinctions between restorative, affective, cognitive, and learning outcomes. Studies should also move beyond visual variables and examine multisensory dimensions such as soundscapes, dynamic light, interaction, movement, and embodied navigation. Most importantly, future work should investigate whether improvements in comfort, restoration, or attention translate into measurable learning benefits such as memory retention, comprehension, problem-solving, creativity, or long-term engagement.

5. Conclusions

This narrative review examined the emerging intersection between biophilic design, virtual reality, and learning environments. From an initial set of 69 records identified through Scopus and Web of Science, five studies met the inclusion criteria. The limited size of the final corpus confirms that this field remains in its early stages, despite its relevance to architectural design, immersive technologies, and educational innovation. The review suggests that biophilic design can contribute to the environmental quality of VR and digitally simulated learning spaces. Its value lies not simply in reproducing natural scenery, but in shaping spatial conditions that may support attention, comfort, restoration, emotional regulation, and satisfaction. Direct references to nature, such as greenery, natural views, daylight, and large windows, and indirect references, such as wood finishes, biomorphic patterns, curved forms, and organic geometries, both appear relevant for the design of immersive educational environments. However, the findings also indicate that biophilic VR design should be applied critically and contextually. Biophilic elements are not universally beneficial across all learning conditions, and their effectiveness may depend on the task, the learner group, the intensity of stimulation, and the intended cognitive or emotional state. For this reason, biophilic design should be understood as an environmental regulation strategy rather than as a decorative layer.

The main contribution of this review is to frame VR learning environments as spatial environments that require architectural attention. As immersive technologies become more common in education, architects and designers can contribute by integrating principles of environmental psychology, neuroarchitecture, and human-centered design into virtual and hybrid learning spaces. Future research should move beyond short-term measures of comfort and restoration to examine learning-specific outcomes, including memory retention, comprehension, creativity, engagement, and long-term well-being.

In conclusion, biophilic design offers a promising but still underexplored framework for creating VR learning environments that are not only technologically effective but also cognitively manageable, emotionally supportive, and responsive to human needs.

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