

RECOGNIZING THE CLASSROOM ENVIRONMENT AS A DYNAMIC CONTRIBUTOR TO PHYSICAL HEALTH, COGNITIVE ABILITIES, AND SOCIAL WELL-BEING

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ABSTRACT

This study explores how human-centered environmental design affects students' general well-being, cognitive function, and health in learning environments. It examines how physical and sensory surroundings impact students' and teachers' health by influencing bodily functions, mental states, and social relationships. It does this by drawing on data from environmental psychology, ergonomics, and user experience design. The findings reveal that spaces integrating natural elements with adjustable ergonomic design and providing accessible areas for everyone create optimal conditions that enhance attention, reduce stress, and promote better overall health. The study highlights significant gaps in research focusing on long-term monitoring of subjects exposed to various sensory stimuli in real-world settings. It emphasizes the need for collaboration across multiple disciplines in educational space design to develop learning environments that foster student cognitive development and safeguard their health and well-being.

Keywords: Classroom environment, Physical health, Social well-being, Evidence-based design

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INTRODUCTION

Educational settings are crucial for mental and physical well-being as they are hubs of intense cognitive and social activity. Students spend the majority of their school hours indoors, and poorly designed spaces lacking adequate lighting, experiencing excessive noise and uncomfortable temperatures, and requiring students to remain seated can lead to fatigue and stress.

Exposure to subpar indoor environments can impact attention span and mood negatively. Research suggests that Human-Centered Design (HCD) can help alleviate these issues by creating spaces that cater to human needs, emotional well-being, and health standards [1-5]. In order to investigate how various aspects of educational space design affect students'

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physical health, mental health, and social interactions, this review explores research from a variety of pertinent domains. The research bridges the gap between environmental psychology and educational design to meet human requirements for learning spaces by identifying universal methodologies that help designers create better learning environments, drawing from healthcare, education, and occupational design [6, 7]. The following research questions serve as the study's compass:

A theoretical framework that takes into account both the experience dimension of users and the psychological mechanisms through which surroundings influence human behavior is necessary to create environments that promote health, cognitive function, and well-being.

A key technique for developing learning environments that accommodate user demands and preferences is HCD. This design methodology, which is based on user-centered research, requires designers to show empathy and participate in several cycles of problem-solving with consumers during the design process. In order to share their expertise for creating operational systems, technical systems, sensory environments, and physical places, educators, administrators, and students should actively engage in HCD. The authors stress that important design insights come from users' everyday habits and implicit knowledge. Co-design creates environments that accurately represent cultural context, learning styles, neurodiversity, and emotional requirements by actively participating in the conception and prototype of design interventions [8-10].

By designing areas that improve comfort and promote efficient communication, the co-design framework is especially helpful for handling circumstances that call for extra care. Due to students' varied mental

work demands, sensory sensitivity, social connections, and emotional regulation needs during the school day, these concepts—which are crucial in daily life—are equally significant in educational settings. In order to create solutions that incorporate both practical knowledge and scientific data, researchers must co-design frameworks that blend evidence-based and experience-driven approaches. This study emphasizes its dual focus, which is in line with research goals to develop learning environments that combine natural features with ergonomic technology design and sensory-based methods.

The design philosophies supported by Universal Design and Universal Design for Learning are consistent with the principles of HCD. These frameworks place a strong emphasis on flexible learning environments that are completely accessible to students with a range of learning requirements. By affecting people's views, emotional health, and personal freedom, the authors demonstrate how environmental influences can either lessen or increase social inequality [11, 12]. Human-centered and inclusive design techniques foster a feeling of community and increased student involvement by incorporating strategies that adjust to cultural norms and environmental situations, according to research done in educational settings.

Through cooperative engagement and compassionate techniques, the HCD design framework enables organizations to build spaces. Environmental elements that affect human health, behavior, and thought processes are identified by environmental psychology. By fusing students' immediate experiences with their innate biological reactions, these three ideas show how educational settings operate as complex active systems that support learning outcomes. Using an integrated theoretical framework, the review demonstrates that

learning environments that prioritize people and incorporate evidence-based design elements like natural features, ergonomic support, technological awareness, and sensory stimulation will create the best possible conditions for the health of students and educators.

METHODOLOGY

To investigate empirical and theoretical research on the connections between educational design and health outcomes, a review of the literature was done. The evaluation sought to improve the study's clarity and transparency using a five-stage methodology that was influenced by PRISMA principles. Google Scholar, PubMed, Web of Science, and Scopus were among the databases examined. The study found peer-reviewed papers published between 2014 and 2024 in Scopus, Web of Science, PubMed, and Google Scholar using scoping review techniques. A total of 90 studies were included following screening and quality evaluation [13-17].

FUNDAMENTAL ENVIRONMENTAL PARAMETERS

Extensive evidence demonstrates the interconnectedness of various environmental factors in educational spaces: lighting affects circadian rhythms, acoustics influence stress levels, air quality impacts cognitive function, and biophilia enhances attention. By considering these factors collectively, a human-centered educational approach emerges, recognizing the classroom environment as a dynamic contributor to physical health, cognitive abilities, and social well-being, rather than merely a backdrop for learning.

Lighting

Lighting has a direct impact on circadian rhythm, visual comfort, attentiveness, and cognitive function, making it an essential component of school design. Higher academic attainment and better wellbeing are associated with sunshine exposure,

according to research. Children in schools with more daylight have advanced in reading and math more quickly than those with less daylight. Additionally, daylight exposure promotes improved sleep, alertness, and memory consolidation via regulating melatonin and biological clocks. On the other hand, glare, uneven illumination, and extreme contrast might exacerbate students' visual fatigue, headaches, and cognitive stress. According to recent research, dynamic lighting systems that change brightness and color temperature throughout the day can imitate circadian rhythms and improve teachers' and students' mood and arousal. Proper placement, orientation, and windows with good views are crucial for lighting and providing restorative sights [18-20]. Views of green natural surroundings have been found to enhance student attention and reduce cognitive fatigue. Students in classrooms with extensive natural views reported lower stress levels and increased focus. University students in halls with natural views showed improved mood, alertness, and task performance.

Noise Control

Acoustic quality is vital for concentration, stress management, and effective communication in educational settings. Noisy classrooms have been linked to poor reading comprehension and higher stress levels in children. Continuous noise can impact verbal memory, leading to mental exhaustion and disengagement. Well-designed learning spaces utilize absorbent materials like acoustic panels, carpets, and upholstered furniture to reduce reverberation and enhance speech intelligibility. Studies in elementary schools have shown average reverberation times during learning tasks to be around 0.4 seconds, often below 0.6 seconds. Proper acoustic design in healthcare settings has been found to reduce stress and improve

trust between caregivers and patients. Quiet zones and sound control in classrooms benefit teachers' well-being and students' attention and engagement [21, 22]. Zoning with partitions, ceiling baffles, and varied surfaces helps prevent sound interference, promoting active learning. Background sounds like nature or soft music can boost attention and creativity, while mechanical or urban noises can be distracting.

Air Quality and Thermal Setting

Indoor air quality (IAQ) and thermal comfort play a crucial role in maintaining physiological and cognitive processes. Poor IAQ, characterized by high levels of CO₂, air pollutants, or inadequate ventilation, has been linked to headaches, sleepiness, and impaired decision-making. Thermal comfort also affects attention and fatigue levels. Classroom temperatures exceeding 26°C or falling below 20°C can diminish working memory and problem-solving skills. Sustainable design elements like cross-ventilation, optimal ceiling heights, and operable windows contribute to comfort and support more sustainable building designs. Better IAQ can lead to improved public health by reducing absenteeism due to respiratory issues and allergies [23, 24].

Building structure and interior design

Spatial arrangement impacts posture, mobility, collaboration, and inclusion. Flexible designs cater to various teaching styles, promoting both solitary and collaborative learning while adhering to ergonomic principles. Activity-promoting designs help reduce sedentary behavior and musculoskeletal disorders. Ergonomic interventions such as adjustable desks and dynamic seating encourage posture variability and muscle activity. Classrooms incorporating active furniture like standing desks have shown reduced sitting time, though the impact on academic performance remains inconclusive. Thoughtful spatial design influences social

behavior, fostering collaboration and minimizing disruptions.

Color Tone

Color psychology significantly influences emotional control and learning outcomes. Warm colors like orange and yellow encourage sociability and enthusiasm, while cool colors such as blue and green promote relaxation, concentration, and control. Color preferences vary by age and cultural background, necessitating adaptation to context and school environments. Balanced color schemes prevent overwhelming or monotonous aesthetics, reducing anxiety and aiding wayfinding. Incorporating natural materials and maintaining aesthetic integrity fosters a sense of belonging and pride, enhancing place attachment and motivation [25, 27].

Biophilic Texture

Biophilic design, rooted in humans' deep connection to nature, is a fundamental design approach that aims to enhance well-being experiences within educational settings. The incorporation of vegetation, natural materials, and bio-inspired patterns has been shown to reduce anxiety, improve attention restoration, and boost creative thinking. Direct and indirect elements, such as indoor plants, living walls, outdoor classrooms, and nature-inspired materials, can all contribute to these positive experiences. Additionally, natural elements like plants and materials can enhance indoor humidity control and sound absorption, benefiting overall health.

HEALTH AND WELL-BEING IMPACT

Physiological Impact

Physiological outcomes refer to measurable changes in bodily systems, including cardiovascular, respiratory, endocrine, and immune functions, resulting from environmental conditions. In educational environments, building characteristics significantly affect occupants' physiological

well-being. Factors like air quality and thermal comfort play a crucial role in stress physiology and overall physical health.

Physical activity is a well-studied physiological phenomenon with substantial research supporting its benefits. Buildings designed to promote physical activity, such as those with walkable layouts, open staircases, and outdoor learning spaces, help reduce sedentary behavior. Increased physical activity levels in children can lower obesity risk, enhance cardiovascular health, and regulate metabolism. Accessible playgrounds and well-designed school courtyards encourage spontaneous physical play, supporting children's physical development [28-30].

Indoor air quality can impact various health outcomes, leading to respiratory issues and decreased blood oxygen levels when ventilation is inadequate or harmful compounds are present. Improved ventilation systems and eco-friendly building materials can reduce asthma cases and respiratory problems. Designs incorporating natural ventilation, vegetation, and operable windows can enhance air circulation and humidity management, promoting pollutant removal. The body regulates temperature through hormonal and autonomic responses to maintain comfort across different thermal conditions. Thermal discomfort can lead to decreased focus and increased fatigue. Lighting and circadian rhythms influence alertness and sleep quality. Dynamic circadian lighting systems in educational facilities improve sleep patterns, enhance daytime alertness, and support physical recovery and academic performance.

Research utilizing salivary cortisol and heart rate variability biomarkers demonstrates that spending time in supportive environments with natural light and appealing design can help individuals manage chronic stress effectively.

Psychological Impact

People's psychological well-being is influenced by their emotional responses, stress levels, mood, and self-reported health status, which are impacted by their environment and current location. Students' psychological state directly affects their motivation levels, attendance, and ability to focus on learning activities. According to research in environmental psychology, well-designed areas can encourage social interaction, self-determination, and relaxation. Humans can restore their attentional resources by spending time in restorative settings with natural elements and intricate visual patterns. Views of nature can elicit happy emotions and help with stress recovery through parasympathetic reactions. According to studies, educational facilities with gardens, green walls, and natural lighting systems might lessen students' mental exhaustion and worry [31, 32].

Acoustics and lighting have an impact on how we feel about ourselves. While adequate illumination can enhance both physical and mental health, poor acoustics can cause irritation and mental tiredness. Good lighting conditions can enhance emotional well-being and mood. Research reveals that classrooms receiving natural daylight provide better learning environments, leading to reduced depression symptoms and higher satisfaction among students and teachers. By enabling individuals to control aspects of their environment such as temperature, lighting, and spatial arrangement, higher autonomy levels can be achieved, resulting in improved health outcomes and greater satisfaction.

Environmental design plays a crucial role in connecting emotional well-being with physical health through psychological effects. Designers can create environments that support mental wellness and academic

success by minimizing stressors and fostering positive emotions in their designs. Clear views, simple access, and adaptable locations promote social contact and teamwork in terms of social and behavioral results. For example, open-plan classroom designs with transparent walls and shared commons can improve connections, encourage peer engagement, and lessen social isolation. Behavioral health is influenced by physical design, which has an impact on risk-taking, safe mobility, and levels of physical exercise. Promoting active habits is greatly aided by features like outdoor learning areas and walking circulation pathways [33, 34].

Social Impact

Human-Centered Design promotes social cohesion by facilitating relationship-building within local communities. People tend to stay longer in environments they perceive as safe and organized, while feeling threatened or finding navigation difficult can drive them away. Educational buildings that provide spaces for casual student-teacher interactions, such as lounges, courtyards, and learning pods, enable collaborative work while maintaining a natural environment.

Cognitive Performance Impact

The physical environment influences people's performance in attention, memory, learning, and problem-solving. Cognitive health is the key indicator of educational facility design success. High CO₂ levels and poor ventilation reduce mental processing speed and decision quality. Research indicates that students perform better on tests with proper lighting and air quality, enhancing concentration and alertness. Cognitive performance and perception are greatly influenced by lighting and natural daylight availability. Classrooms with ample sunlight yield better student outcomes. Circadian lighting helps maintain focus by aligning with natural biological

rhythms. Noise management and acoustic comfort standards are crucial for the project. Prolonged exposure to high background noise impairs speech comprehension and reading abilities. Classrooms with sound insulation and absorptive materials aid speech comprehension and reduce cognitive load. Environmental quality affects cognitive function through psychological well-being. Stress and fatigue decrease working memory and executive function, while peaceful environments enhance mental clarity. Green spaces improve attention and self-regulation. Clear directions, organized spaces, and prominent environmental elements aid navigation and mental mapping [35, 36].

HUMAN-CENTERED AND EVIDENCE-BASED APPROACHES

Participatory and Co-Design

Participatory and co-design approaches focus on involving end users in the design process to ensure that the environment meets their needs, preferences, and culture. This paper explores how integrating end users' needs into the design process and adopting evidence-based approaches can enhance the effectiveness and acceptance of interventions, particularly in complex settings like educational institutions. This approach aims to create environments that are both functional and satisfying by fostering a sense of ownership and relevance among users, including the diverse student populations found in educational and non-educational settings. Outdoor Learning Environment (OLE) project incorporated the community's culture, actively engaged students, and created a dynamic environment that met the users' expectations in educational institutes. Furthermore, this process involves prototyping to continuously improve the environment's dynamics and user engagement, especially in complex settings like healthcare in educational institutions.

However, despite its benefits, involving users in the design process can present challenges, particularly when addressing the health dynamics of student involvement and managing stakeholders' expectations within institutions [37-40].

Universal Design and Inclusion

The goal of universal design (UD) principles is to reduce barriers that may disproportionately affect students with disabilities by making environments functional and accessible for all people, regardless of ability. By integrating flexibility, simplicity, and perceptibility into design elements, UD promotes equality and participation in educational environments, going beyond simple adherence to accessibility standards [41-44].

In addition to improving physical access, inclusive settings also foster social integration and psychological comfort, both of which are critical for both academic performance and good health outcomes. Furniture that supports different learning styles and resources that help students with a range of requirements should be found in educational environments. The UD framework develops environments that support equity and health by incorporating a variety of users in design choices and adhering to human-centered design principles. According to research, using UD principles in educational settings lessens discriminatory practices and creates spaces that promote mental and physical health.

Evidence-Based Design (EBD)

Evidence-Based Design (EBD), which has its roots in healthcare, uses empirical research to produce solutions that improve user pleasure, safety, and health outcomes. By enhancing aspects like natural light distribution, acoustic control, indoor air quality, and spatial organization, educational settings like schools and colleges can profit from EBD concepts.

These elements have an impact on students' general health, stress levels, and academic performance. Research shows that exposure to daylight and views of the outdoors can improve mood, focus, and attendance rates, underscoring the significance of including biophilic design elements in schools. Ergonomic classroom designs and sound management strategies also assist students with sensory sensitivity in controlling their sensory experiences and reducing disturbances. Learning environments can incorporate scientific rigor with user comfort and health-promoting features by fusing human-centered approaches with evidence-based design.

ENCOUNTERED CHALLENGES

Despite its advantages, applying a human-centered and evidence-based design process in educational environments faces challenges related to resource allocation, interdisciplinary collaboration, and maintaining participatory engagement over time. Proper integration requires effective facilitation among diverse stakeholders, ensuring clear communication channels in pursuit of shared goals by academic, design, health, and user communities. Sustaining enthusiasm for participatory approaches may be hindered by financial and policy constraints. Best practices involve embracing adaptability in design processes through adjustments in established protocols, early integration of user insights, ongoing evaluation cycles, and specialized training for designers and academics in line with human-centered design and evidence-based design principles. Addressing issues of equity and inclusivity in application is essential to ensure diverse perspectives are considered in decision-making [45-48].

CONCLUSION

This review offers convincing proof that human-centric environment design has a substantial impact on students' and teachers' physical and emotional health as well as

their cognitive abilities. It has been demonstrated that including natural lighting, peaceful views, better acoustics, healthier indoor air quality, ergonomic features, accessible layouts, and biophilic designs can actively improve student performance and lower stress levels. These results highlight the significance of circumstances that promote health outside of educational settings.

Key research needs are identified by the study, including the need for long-term, multisensory, and ecologically robust studies to investigate the long-term interactions of environmental influences. To increase knowledge in this field of study, it is crucial to promote interdisciplinary collaboration amongst designers, neuroscientists, psychologists, educators, and health experts. Additionally, user involvement and user-centric designs are crucial in this emerging field of knowledge. Teachers may build learning environments that foster resilience, creativity, equity, and long-term success for all students by incorporating health-promoting ideas into their planning, design, and evaluation.

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