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INDOOR ENVIRONMENTAL QUALITY AND ITS ROLE IN ACHIEVING PSYCHOLOGICAL AND PHYSIOLOGICAL COMFORT FOR EDUCATION BUILDINGS

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Abstract:
Sustainable architecture plays a crucial role in addressing the pressing environmental challenges of the 21st century, and the LEED (Leadership in Energy and Environmental Design) rating system serves as a guiding framework for achieving these objectives.
The integration of sustainability principles in interior design has become increasingly important in addressing environmental, economic, and social challenges. This paper explores the activation of sustainability axes in the context of drawing studios within educational architecture environments. By examining innovative methodologies, sustainable materials, and energy-efficient practices, the study aims to create a framework for Indoor Environmental Quality and its role in achieving psychological and physiological comfort for humans with sustainable interior design in educational settings and explores the impact of indoor environmental quality (IEQ) on the psychological and physiological comfort of educational buildings at UQU. Indoor environmental quality encompasses factors such as lighting, thermal comfort (Wargocki, P.,2017), air quality, acoustics, and spatial layout. The study investigates how these IEQ factors influence students' comfort, productivity, and overall well-being in architectural learning environments. Through a review of literature and potentially surveys or case studies of architecture students, the research aims to identify key IEQ elements that contribute to psychological and physiological comfort (Frontczak, M.2011). Findings highlight the importance of optimizing IEQ for enhancing students' learning experiences and well-being in architecture studios and educational settings. The study concludes with recommendations for improving IEQ in architectural education facilities to support students' comfort and performance.

Keywords: IEQ Indoor Environmental Quality, LEED, psychological and physiological comfort; Thermal comfort (TC); Indoor air quality (IAQ); Sick Building Syndrome (SBS) or Building Related Illness (BRI)

INTRODUCTION

The importance of sustainability is increasing in all areas of life, including interior design, where designers strive to integrate sustainability axes into their projects to ensure a positive impact on the environment, economy, and society. The research paper focuses on how to activate the axes of sustainability in interior design using innovative methodologies, sustainable materials, and achieving energy efficiency. Indoor environmental quality (IEQ) in educational buildings significantly impacts students' psychological and physiological comfort, affecting their health, well-being, and academic performance. IEQ encompasses thermal comfort, indoor air quality, visual comfort, and acoustic comfort. Optimizing these factors is crucial for creating a conducive learning environment.
Where Architecture students spend considerable time in studios, labs, and other learning environments where indoor environmental quality (IEQ) can significantly impact their psychological and physiological comfort. Indoor environmental quality encompasses various factors including lighting, thermal comfort, air quality, acoustics, and spatial layout. These elements collectively influence occupants' well-being, productivity, and learning outcomes. For architecture students, whose education involves intensive design work, critiques, and collaborative projects in often enclosed and sometimes densely occupied spaces, the indoor environment can play a critical role in shaping their educational experience. Despite the importance of IEQ in educational settings, there is a need to understand specifically how IEQ factors

affect architecture students' comfort and performance (Bluyssen,2017). This research explore the relationship between IEQ and the psychological and physiological comfort of architecture students, identifying key factors that contribute to their well-being and learning in architectural education environments.

METHODOLOGY

SEARCH STRATEGY

The literature search was conducted in Jan. 2025, with the final data extraction completed in July 2025. This systematic review adheres to the Preferred Reporting Items for Systematic Re-views and Meta-Analyses Sustainable LEED guidelines to ensure transparency. The LEED was divided into 9 phases:
Location & Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Waste Management, Innovation Design, Regional Priority.
“Sustainable Development” is defined to meet the needs of present generation without compromising the ability of future generations to satisfy their own needs, and activating the axes of sustainability in interior design requires a commitment from designers to follow best practices and choose sustainable materials and technologies. Balancing the environmental, economic, social, and cultural axes is essential to ensure the sustainability of interior designs and achieve a positive impact on society and the environment.

Environmental Axis: The environmental axis is one of the most prominent axes of sustainability in interior design and includes reducing the use of natural resources such as water and energy, and minimizing waste production. To achieve this, it is recommended to use recycled materials and long-lasting materials, as well as to design interior spaces in a way that maximizes the use of natural light and ventilation.

Sustainability and indoor environmental quality (IEQ) are interconnected in several ways. Sustainable building practices often aim to enhance IEQ while minimizing environmental impact

Economic Axis: To achieve economic sustainability, interior designers should choose materials and designs that provide long-term cost savings. This includes using smart building technologies that reduce energy consumption, such as smart systems for controlling lighting, heating, and cooling, as well as relying on water and energy-saving devices.

Social Axis: The social axis focuses on achieving comfort and well-being for individuals who live or work in designed spaces. This includes choosing materials that do not contain harmful chemicals and achieving high indoor air quality. This can be achieved using indoor plants, improving ventilation, and eliminating allergy-causing substances. (Bluyssen,2017)

Cultural Axis: This axis concerns respecting and preserving the cultural and historical heritage of the place. It can be activated by integrating local architectural and traditional elements into interior design, enhancing cultural identity and giving a sense of belonging.

Innovative Technologies: The use of innovative technologies such as 3D printing and virtual reality applications can contribute to achieving sustainable designs. These technologies help reduce waste and increase precision in design implementation, achieving savings in time and resources.

The search strategy involved multiple targeted queries focusing on Natural Ventilation and Daylighting, Low-Emission Materials, and Adaptive and Responsive Systems. (R. Yao, B. Li,2009)

Despite the importance of IEQ in educational settings, there is a need to understand specifically how IEQ factors affect architecture students' comfort and performance. This research aims to explore the relationship between IEQ and the psychological and physiological comfort of architecture students, identifying key factors that contribute to their well-being and learning in architectural education environments.

SELECTION CRITERIA

All included articles were peer-reviewed publications written in English between 2009 and 2025, along Conference papers, single case reports, and small case series were excluded. This review focuses on university students, excluding studies populations and on professions other than architecture.

The publications were sorted into a category based on the strength of their relevance to the topic of the review Strong relevance—studies directly examining the relationship between architecture studio culture indoor environmental quality

The publications selected for this systematic research did not address specific topics directly. Consequently, several specialized studies were consulted to provide supplementary in-sights; however, these sources fall outside the established selection criteria, as some were published before 2015 and others do not specifically focus on the design studio or architectural design context.

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RESULTS

Standards and Guidelines for Indoor Environmental Quality

To ensure consistent and acceptable IEQ, various organizations have developed standards and guidelines. These provide a framework for specification and measurement, allowing professionals to assess and improve indoor environments systematically. These standards offer a benchmark for what constitutes acceptable IEQ and provide measurable targets for building performance. The significance of these standards lies in their role as a common language and set of expectations for the industry.

- **ASHRAE Standards**: The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is a leading source of IEQ standards. ASHRAE Standard 62.1 (Ventilation for Acceptable Indoor Air Quality) and Standard 55 (Thermal Environmental Conditions for Human Occupancy) are widely recognized and used globally. These standards delineate minimum ventilation rates and acceptable thermal comfort ranges for different building types and occupancies. The intention is to provide a scientifically backed basis for designing and operating building systems to achieve good IEQ. (R. Yao, B. Li,2009)
- **WELL Building Standard**: Focusing specifically on health and well-being, the WELL Building Standard is a performance-based system for certifying buildings that support occupant health. It covers ten concepts, including air, water, nourishment, light, fitness, comfort, mind, and community. WELL provides a comprehensive framework for designating buildings that prioritize IEQ as a core element of occupant well-being. The importance of WELL is its holistic approach, integrating various aspects of the built environment to promote health.
- **ISO Standards**: The International Organization for Standardization (ISO) also publishes standards relevant to IEQ, such as ISO 7730 (Ergonomics of the thermal environment) and ISO 16000 series (Indoor air quality). These standards offer a global perspective and provide detailed methodologies for measuring and assessing various aspects of IEQ. The purport of ISO standards is to harmonize IEQ practices internationally
- **LEED (Leadership in Energy and Environmental Design)** : While primarily focused on sustainability, LEED also incorporates IEQ as a critical component. LEED credits are awarded for strategies that improve IAQ, thermal comfort, and access to daylight and views. LEED recognizes the essence of IEQ as an integral part of sustainable building design. The connotation of LEED certification often includes an assurance of a higher quality indoor environment.

LEED Certification

Most famous rating system criteria are "LEED" (Leadership in Energy and Environmental Design) & BREEAM" (Building Research Establishment Environmental Assessment Method).

LEED Certification: Created by the U.S. Green Building Council (USGBC) Figure 1

A lot of rating criteria have existed; it discusses the influen
a sustainable building.

LEED Certification:

- Location & Transportation.
- Sustainable Sites.
- Water Efficiency.
- Energy and Atmosphere.
- Materials and Resources.
- Indoor Environmental Quality.
- Waste Management.
- Innovation Design.
- Regional Priority

Figure 1

LEED sustainability rating criteria

Here's how sustainability relates to IEQ

Sustainability and Indoor Environmental Quality (IEQ) are closely linked. Optimizing IEQ, which encompasses factors like air quality, thermal comfort, lighting, and acoustics, is crucial for creating healthy, productive, and sustainable buildings. Strategies to improve IEQ can also reduce energy consumption, further enhancing sustainability. (Wargocki, P.,2017)

1. Improved Occupant Health and Productivity: Sustainable buildings often prioritize IEQ factors like air quality, lighting, and thermal comfort, which contribute to healthier and more productive indoor environments.

2. Resource Efficiency: Sustainable design and operations aim to reduce resource consumption (energy, water) while maintaining or improving IEQ.

3. Green Building Certifications: Systems like LEED (Leadership in Energy and Environmental Design) or WELL Building Standard emphasize IEQ as a key component of sustainability, promoting strategies for better air quality, natural lighting, and occupant comfort.

4. Balancing Energy Efficiency and IEQ: Sustainable buildings need to balance energy-saving measures with maintaining good IEQ. For example, tight building envelopes can impact ventilation and air quality if not managed properly. (Lee, M. C.,2018)

5. Occupant Well-being: Sustainability in buildings increasingly focuses on occupant well-being, where good IEQ contributes to both sustainability goals and enhanced occupant experience.

Key Considerations

Indoor Environmental Quality is the holistic condition within a building that impacts occupant health, psychological and physiological comfort.

The definition of Indoor Environmental Quality, often shortened to IEQ, in its most straightforward statement, refers to the conditions inside buildings. These conditions directly affect the health, comfort, and well-being Meaning → Well-being encompasses holistic health and happiness, supported by sustainable lifestyle choices that benefit both individuals and the environment. of occupants. Understanding IEQ begins with recognizing that it is not a single factor, but rather a designation for a combination of environmental elements. (Clements-Croome, D.,2018)

To provide a clearer explanation, consider IEQ as the air we breathe, the temperature around us, the light we see, and the sounds we hear within an enclosed space. Each of these components plays a vital role in how we experience and react to an indoor environment. Poor IEQ can lead to a range of negative outcomes, from minor discomfort like headaches and fatigue to more serious health issues like respiratory problems and allergies. So, Why Indoor Environmental Quality Matters?

The meaning of prioritizing IEQ extends far beyond simple comfort. It has profound implications for health, productivity, and even organizational success. In workplaces, schools, and homes, the quality of the indoor environment directly impacts the occupants in numerous ways.

1. **Health Impacts:** Poor IEQ is directly linked to a range of health problems, psychological and physiological comfort often referred to as Sick Building Syndrome (SBS) or Building Related Illness (BRI). These can include respiratory illnesses, allergies, asthma exacerbation, headaches, fatigue, and skin irritation. Long-term exposure to poor IAQ can even contribute to more serious conditions. Clarification of this link is vital for understanding the health-related significance of IEQ.

2. **Productivity and Performance**: Studies have consistently shown a correlation between good IEQ and increased productivity and performance. In offices and schools, optimizing thermal comfort, IAQ, lighting, and acoustics can lead to improved concentration, reduced absenteeism, and enhanced cognitive function. The essence of a productive environment is often tied to the quality of the air and space in which people operate.
3. **Well-being and Mood**: Beyond physical health and productivity, IEQ significantly influences emotional well-being. Natural light, comfortable temperatures, and quiet spaces can improve mood, reduce stress, and enhance overall satisfaction. Conversely, poor IEQ can contribute to irritability, anxiety, and decreased morale. The connotation of a building's environment is strongly tied to the emotional state of its occupants.
4. **Sustainability and Energy Efficiency**: While seemingly separate, IEQ and sustainability are intrinsically linked. Strategies to improve IEQ, such as natural ventilation and daylighting, can also reduce energy consumption. Conversely, energy-efficient building designs must carefully consider IEQ to ensure that energy savings do not come at the expense of occupant health and comfort. The denotation of a sustainable building now increasingly includes a commitment to high IEQ.
In summary, understanding the fundamentals of Indoor Environmental Quality is essential for creating healthy, productive, and sustainable buildings. It is a multifaceted concept that requires careful consideration of air quality, thermal comfort, lighting, and acoustics, all working in concert to benefit the occupants. The statement is clear → IEQ is not just a desirable feature, but a fundamental requirement for modern buildings.

Key Components of Indoor Environmental Quality and its Impact on Psychological and Physiological Comfort

A comprehensive description of IEQ necessitates breaking it down into its primary constituents. These are the fundamental aspects that, when properly managed, result in a high-quality indoor environment. Monitoring and Measurement Techniques. Figure 2
Effective IEQ management relies on accurate monitoring and measurement. Clarification of IEQ status requires quantifiable data, and various technologies and methods are available to assess the different components of IEQ. The explication of these techniques is crucial for professionals responsible for maintaining healthy indoor environments. (Carmona N. et al.,2022)
Indoor Air Quality (IAQ) Natural Ventilation , Thermal Comfort , Daylighting and Visual Comfort, Acoustics, Low-Emission Materials, Adaptive and Responsive Systems.

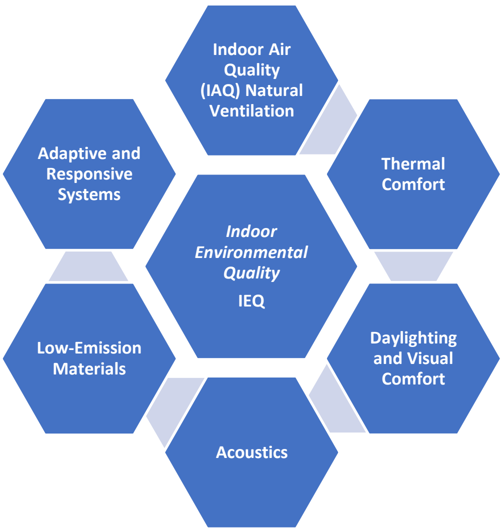


Figure 2
Indoor Environmental Quality and its
Impact on Psychological and Physiological Comfort

- **Indoor Air Quality (IAQ) Natural Ventilation**: This is perhaps the most frequently discussed component. IAQ relates to the substance of the air inside, focusing on pollutants such as volatile organic compounds (VOCs), particulate matter, carbon dioxide, and biological contaminants like mold and bacteria. Specification of good IAQ involves minimizing these pollutants to levels that are considered safe, healthy, and the Indoor Air Quality (IAQ) Monitoring by using:

- **Portable Monitors**: These devices can measure a range of pollutants in real-time, including VOCs, particulate matter (PM2.5, PM10), carbon dioxide (CO2), carbon monoxide (CO), and humidity. They are useful for spot checks and initial assessments. The sense of immediacy with portable monitors provides quick insights into IAQ issues.
- **Continuous Monitoring Systems**: For ongoing IAQ management, permanently installed sensors provide continuous data streams. These systems can trigger alerts when pollutant levels exceed pre-set thresholds, enabling timely intervention. The intention of continuous monitoring is proactive IAQ management. (D. Nosham,2024)
- **Laboratory Analysis**: For detailed analysis of specific pollutants, air samples can be collected and sent to laboratories. This is particularly useful for identifying mold spores, allergens, and specific VOCs. The substance of lab analysis offers a deeper understanding of complex IAQ problems. (D. Nosham,2024)

Indoor air pollution: Given that people spend 85% to 90% of their time indoors, the quality of indoor air is likely to have a significant impact on health, even though it is outdoor air that is regulated (Klepeis, N. E. et al. 2001) . EPA exposure studies indicate that indoor levels of pollutants may be two to five times, and occasionally more than 100 times, higher than outdoor levels (USEPA,2015). Some indoor gaseous air pollutants can be emitted by materials in the building, furniture finishes, paints, adhesive and particle board (Hemond, H.2015). Indoor sources of particles include gas-fired appliances, cooking, vacuuming/cleaning activities and the generation of particles by people. Figure3 (Carmona N. et al.,2022)

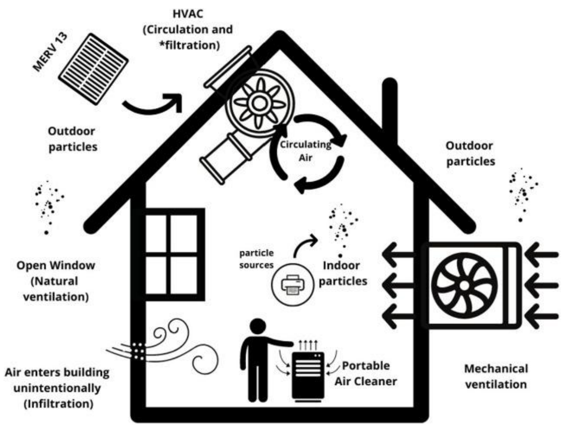


Figure 3
Indoor Air Pollution Dynamics (Carmona N. et al.,2022)

Indoor air quality (IAQ) is paramount for sustainable IEQ. Poor IAQ can lead to respiratory illnesses, allergies, and reduced cognitive function (Zhang et al., 2016). To enhance IAQ, buildings should incorporate efficient ventilation systems that ensure the regular exchange of indoor and outdoor air, alongside the use of low-VOC (volatile organic compounds) materials to mitigate harmful emissions. Strategies such as Engineering controls Figure3, indoor plant incorporation and air purification systems can also improve air quality by filtering pollutants (Wargocki et al., 2017)

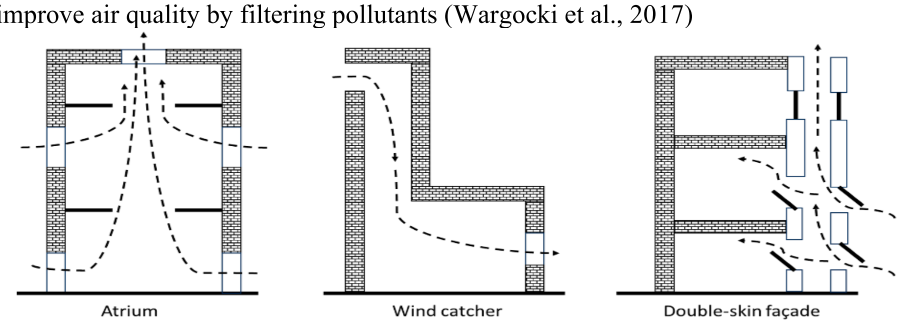
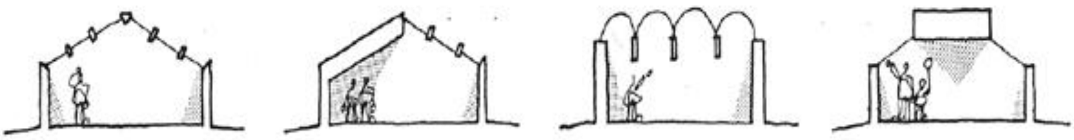


Figure 4 Engineering controls for indoor air quality (IAQ) (Li, Simon. 2023). Simplified schematics of atrium, wind tower, and double-skin façade as the treatments, and its Impact on Psychological and Physiological Comfort

- **Thermal Comfort**: This designation pertains to temperature, humidity, air movement, and radiant temperature. Achieving thermal comfort means creating an environment where occupants feel neither too hot nor too cold, and where humidity levels are appropriate to prevent discomfort and health issues. The sense of thermal comfort is subjective but can be objectively measured and managed through building systems. (Wargocki, P. et al., ,2017) also, Thermal Comfort Assessment by:
- **Temperature and Humidity Sensors**: Basic but essential, these sensors provide data on temperature and relative humidity, key parameters for thermal comfort. The denotation of thermal comfort starts with these fundamental measurements.
- **Anemometers**: Used to measure air velocity, which is important for assessing draft risk and ventilation effectiveness. The implication of air movement on thermal comfort is significant.
- **Radiant Temperature Sensors**: These measure the temperature of surrounding surfaces, which can significantly impact thermal comfort, especially near windows or cold walls. The import of radiant temperatures in overall thermal experience is often overlooked.
- **Effects of cardiovascular diseases on thermal response**: Clinical data indicate that people with cardiovascular diseases may be more vulnerable to heat stress, and the mortality rate was 30% greater than those without cardiovascular diseases 30. In patients with cardiovascular diseases, hemodynamic factors will cause changes in cardiac output, systemic circulation, and hence skin blood flow. The incorporation of the CVS in the thermoregulation model extends our knowledge about cardiovascular function in thermoregulation and enables us to study the effects of different types of cardiovascular diseases, and severity (mild, moderate, and severe), on body core temperature. (Zhang et al., 2016)
- **Daylighting and Visual Comfort**: The interpretation of lighting within IEQ goes beyond mere illumination. It includes the type, intensity, and distribution of both natural and artificial light. Optimal lighting supports visual tasks, reduces eye strain, and positively influences mood and circadian rhythms. Poor lighting, on the other hand, can lead to headaches, fatigue, and reduced productivity. The intention behind good lighting design is to mimic natural daylight as closely as possible and provide appropriate artificial light where needed Figure5,6. Also, Lighting measurements by:
- **Lux Meters**: Measure illuminance levels (light intensity) in lux. or foot-candles, ensuring adequate lighting for visual tasks. The specification of lighting levels is crucial for visual comfort and productivity. (Valeria De Giuli,2018)



Two sides One side Up lighting Drop lighting

Figure 5
Controlling natural lighting and its effect on changing the shape of the exterior building form.

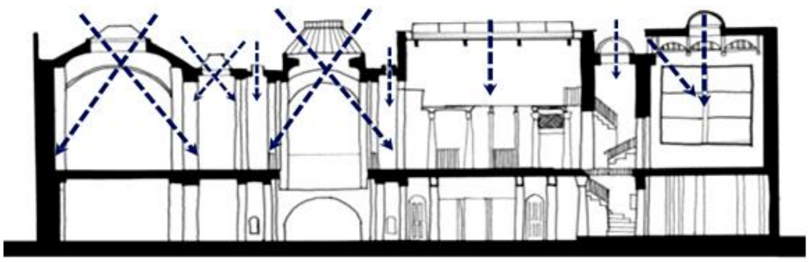


Figure 6
Mixed lighting and ventilation control of building

- **Visual Comfort:** Adequate lighting, both natural and artificial, is crucial. Poor lighting can cause eye strain, headaches, and fatigue, impacting students' ability to focus. (M. Fakhari,2021)
- **Acoustics**: Sound levels and sound quality are crucial elements of IEQ. Excessive noise can be disruptive and stressful, while poor acoustics can make it difficult to understand speech or concentrate. Effective acoustic design aims to control noise levels, reduce reverberation, and create a sound

environment that is conducive to the intended use of the space. The import of acoustics is often underestimated, yet it significantly affects occupant well-being, performance and Acoustic Measurement:

- **Sound Level Meters**: Measure sound pressure levels in decibels (dB), used to assess noise levels and identify areas with excessive noise. The designation of acceptable noise levels is vital for acoustic comfort. (N. Mahyuddin et al,2019)
- **Acoustic Testing**: More comprehensive acoustic assessments involve measuring reverberation time, sound transmission loss, and speech intelligibility to evaluate the overall acoustic performance of a space. The essence of good acoustics goes beyond simple noise reduction.
- **Low-Emission Materials:** In an era where sustainability is paramount, the selection and management of materials and resources have become crucial in reducing environmental impacts and promoting a circular economy. This focus encompasses sustainable materials, product lifecycle considerations, and new innovations in material science. Using materials with low VOC (volatile organic compound) emissions contributes to better indoor air quality, aligning sustainability and IEQ goals by using sustainable martials.
- **Sustainable materials** are those that are sourced, produced, and utilized with minimal impact on the environment. These materials often have lower embodied energy, reduced toxicity, and are derived from renewable resources. Examples include recycled metals, reclaimed wood, bamboo, and bio-based composites. Utilizing sustainable materials not only curtails the depletion of natural resources but also supports waste reduction efforts and minimizes greenhouse gas emissions throughout the production process (Lehmann et al., 2020).
- **Product Lifecycle:** The product lifecycle encompasses various stages from raw material extraction, manufacturing, and usage to disposal or recycling. Understanding and optimizing these stages can significantly reduce environmental impacts. Life cycle assessment (LCA) is a powerful tool that evaluates the ecological footprint of products over their lifespan, helping stakeholders make informed decisions about materials and construction methods. By focusing on life cycle thinking, industries can identify opportunities for reducing resource consumption and improving overall sustainability (Huppes & Ishikawa, 2009).
- **New Innovations:** Innovative approaches in material science are pivotal in advancing sustainable practices. Recent developments include the creation of self-healing concrete, which can autonomously repair cracks, and bioplastics, which are derived from natural substances and can decompose more readily than traditional plastics. Additionally, technologies such as 3D printing allow for more efficient use of materials, reducing waste by fabricating components on-demand (Kinsley et al., 2021). Such innovations not only contribute to resource efficiency but also open new avenues for sustainable construction and manufacturing.
- So, Ultimately, focusing on sustainable materials, understanding product lifecycles, and leveraging new innovations are essential strategies for promoting sustainable practices within industries. Together, they help create a more sustainable future by mitigating resource depletion and environmental degradation. Figure7

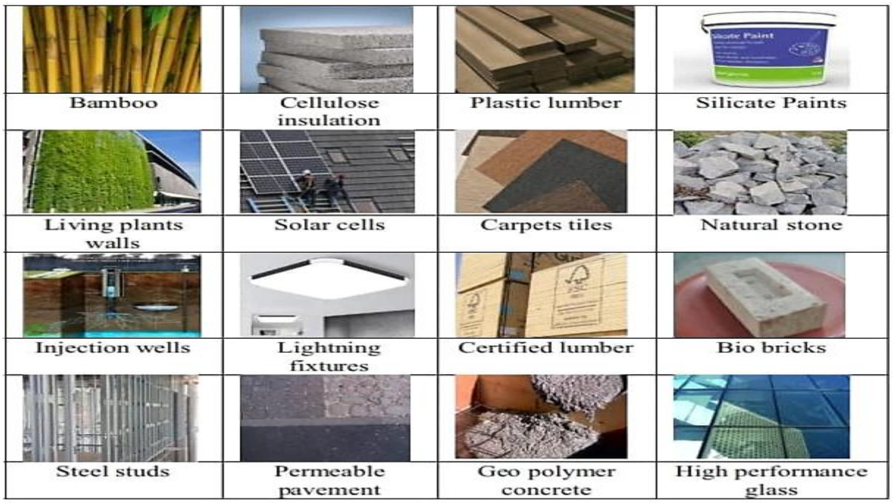


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Figure 7 Using Low-Emission Materials in educational buildings to support the Psychological and Physiological Comfort

- **Adaptive and Responsive Systems**: Sustainable buildings might incorporate adaptive systems that respond to occupant needs for comfort and IEQ. (Lee, M. C.,2018)

Using Engineering controls for indoor air quality (IAQ) from a systems design perspective. As a result of the review, content into three categories: (Li, Simon. 2023)
(1) indoor air treatments.
(2) dissemination control strategies.
(3) information technology.

Indoor air treatments can be generally interpreted as the “cleaning” aspect, which covers ventilation and contaminant removal techniques. Dissemination control focuses on how contaminants generated in an indoor space can be transmitted. The category of information technology discusses IAQ sensors for monitoring, as well as the applications of the Internet of Things and IAQ data. Then, It can be further analyze the reviewed engineering controls by performing systems and functional analysis. Along with a discussion of IAQ functions, we suggest some systems design techniques, such as functional decoupling and design for flexibility/resilience, which are expected to promote more systems thinking in designing IAQ solutions. (Li, Simon. 2023)

So, prioritizing sustainable indoor environmental quality through improved air quality, thermal comfort, effective lighting, and acoustic management is essential for promoting health and well-being in built environments. Committing to these principles not only enhances occupant satisfaction but also contributes to environmental sustainability.

Case Study: College of Engineering and Architecture, Umm Al-Qura University, Makkah, KSA.

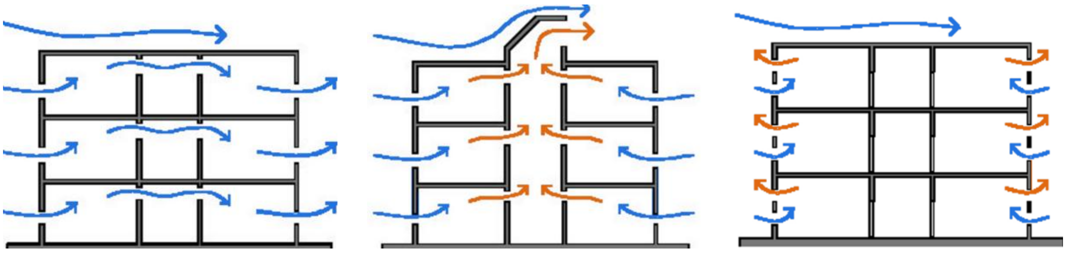
Table 1 Indoor Environmental Quality and its Impact on Psychological and Physiological Comfort

NO.	Key Components of (IAQ)	The Impact on Psychological and Physiological Comfort
1	Indoor Air Quality (IAQ) Natural Ventilation 	*Natural Ventilation* is perhaps the most frequently discussed component. IAQ relates to the substance of the air inside, focusing on pollutants such as volatile organic compounds (VOCs), particulate matter, carbon dioxide, and biological contaminants like mold and bacteria. Specification of good IAQ involves minimizing these pollutants to levels that are considered safe and healthy.
2	Thermal Comfort 	*Thermal Comfort*: This designation pertains to temperature, humidity, air movement, and radiant temperature. Achieving thermal comfort means creating an environment where occupants feel neither too hot nor too cold, and where humidity levels are appropriate to prevent discomfort and health issues. The sense of thermal comfort is subjective but can be objectively measured and managed through building systems.
3	Daylighting & Visual Comfort 	*Daylighting:* The interpretation of lighting within IEQ goes beyond mere illumination. It includes the type, intensity, and distribution of both natural and artificial light. Optimal lighting supports visual tasks, reduces eye strain, and positively influences mood and circadian rhythms. Poor lighting, on the other hand, can lead to headaches, fatigue, and reduced productivity. The intention behind a good lighting design is to mimic natural daylight as closely as possible and provide appropriate artificial light where needed. *Visual Comfort*: Adequate lighting, both natural and artificial, is crucial. Poor lighting can cause eye strain, headaches, and fatigue, impacting students' ability to focus.
4	Acoustics 	*Sound levels and sound quality* are crucial elements of IEQ. Excessive noise can be disruptive and stressful, while poor acoustics can make it difficult to understand speech or concentrate. Effective acoustic design aims to control noise levels, reduce reverberation, and create a sound environment that is conducive to the intended use of the space. The import of acoustics is often underestimated, yet it significantly affects occupant well-being and performance.

NO.	Key Components of (IAQ)	The Impact on Psychological and Physiological Comfort
5	Low-Emission Materials 	*Using materials with low VOC* (volatile organic compound) emissions contributes to better indoor air quality, aligning with sustainability and IEQ goals.
6	Adaptive and Responsive Systems 	*Sustainable buildings* might incorporate adaptive systems that respond to occupant needs for comfort and IEQ and using Engineering controls for indoor air quality (IAQ).

(researchers,2025) *Case Study: College of Engineering and Architecture, Umm Al-Qura University, Makkah , KSA. Natural Ventilation and Psychological & Physiological Comfort* Figure8,9

Figure 8 Natural Ventilation - Umm Al-Qura University (researchers,2025)



Wind-driven cross ventilation occurs via ventilation openings on opposite sides of an enclosed space.

Buoyancy-Driven Stack Ventilation relies on density differences to draw cool, outdoor air in and hot out.

Single-sided ventilation typically serves single rooms and thus provides a local ventilation solution.

Figure 9 Natural Ventilation and Psychological & Physiological Comfort Umm Al-Qura University

Thermal Comfort and Psychological & Physiological Comfort
Protection from heat can be improved by using innovative designs like the structure shown in the image, which provides an open space shielded from the elements. Instead of tents, fixed structures such as transparent roofs or retractable canopies can offer protection from heat, cold, and rain. This design enhances comfort and makes use of natural light, creating an inviting environment. By investing in these solutions, we can improve the user experience and adapt easily to climate challenges and Psychological & Physiological Comfort. Figure10

Figure 10 Thermal Comfort and Psychological & Physiological Comfort - - Umm Al-Qura University (researchers,2025)

Daylighting & Visual Comfort and Psychological & Physiological Comfort:

Regulating natural lighting and its impact on shaping the building's exterior façade Figure11,12, along with the distribution of artificial lighting in functional areas such as classrooms, libraries, corridors, and administrative offices. (Elhamy,Khalil,2024)

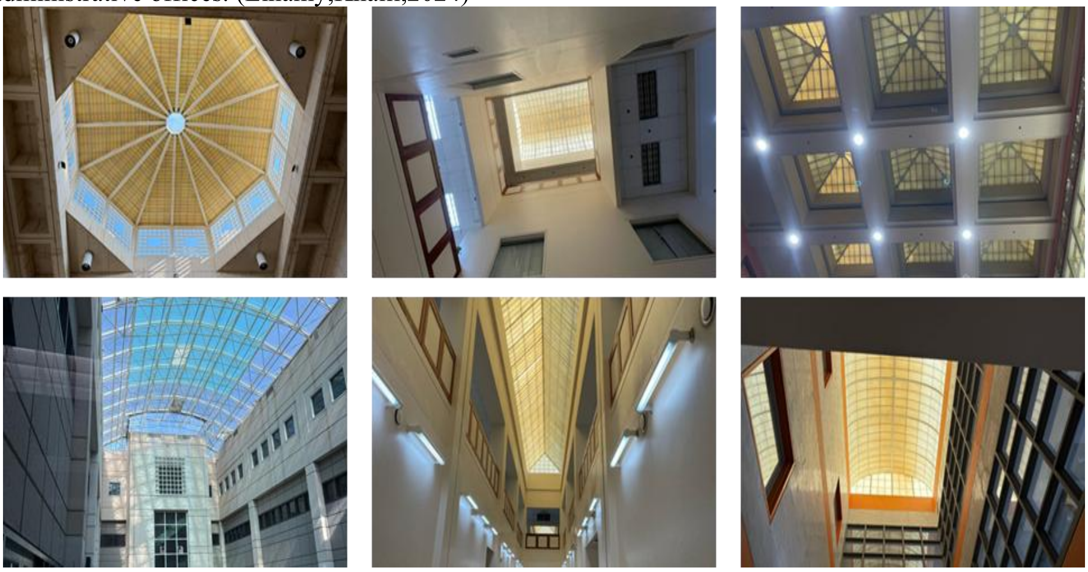


Figure **11** Natural Lighting At Umm Al-Qura University Enhances Learning Quality and Psychological and Physiological Comfort. (researchers,2025)

Figure **12** The Integration Between Natural Lighting & Artificial Lighting to Visual Comfort at Umm Al-Qura University for Psychological & Physiological Comfort (Elhamy,Khalil,2024)

Acoustics and Psychological & Physiological Comfort

Noise pollution and poor acoustics are well-documented detractors of cognitive performance. Background noise, especially speech, can interfere with concentration and memory. Acoustic design that minimizes distractions and promotes speech clarity is crucial for learning and working environments.

Controlling noise at the source for lecture rooms and studios.

Controlling noise along its path Reflected sound may be reduced by placing sound absorbing materials on surfaces from which sound will be reflected.

Controlling noise at the receiver Direct ear protection (ear plugs or earmuffs) is often used to protect workers' hearing when source and path noise control are not practical or possible (Temporary) Enclose the listener in an acoustically effective enclosure or Room (Permanent) Figure13

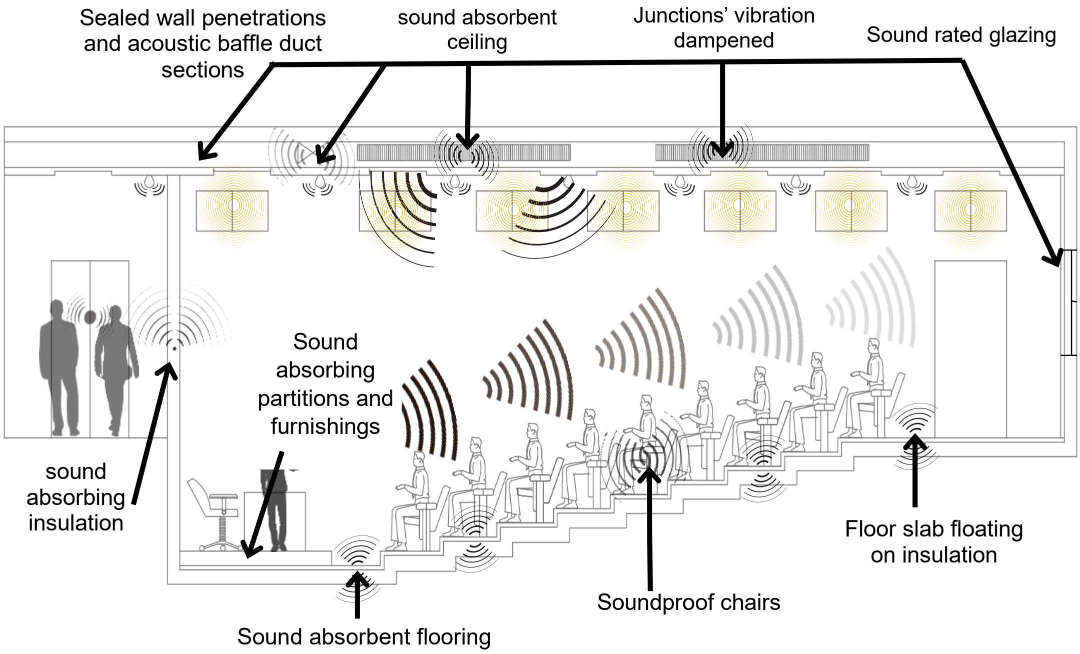


Figure **13** Attributes of Good Acoustic Quality in lecture rooms at Umm Al-Qura University for Psychological & Physiological Comfort (researchers,2025)

Low-Emission Materials

A sustainable material is a natural raw material that is renewable or can be recycled without adding any physical or chemical treatments that change its environmental properties, used in a way that minimizes their negative impact on the environment and human health. Figure14

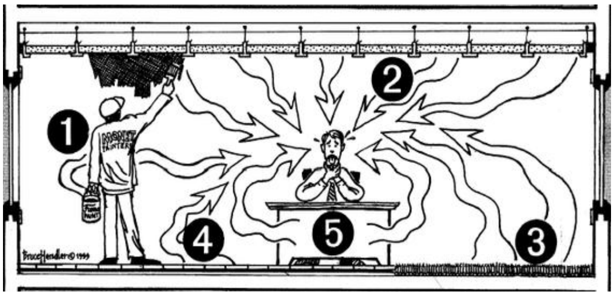


Figure **14**1- Paints 2- Ceiling tiles 3- Carpeting 4- VCT floor tiles 5- Manufactured wood products Sources of Off gassing in Building Materials

Adaptive and Responsive Systems

Sustainable buildings might incorporate adaptive systems that respond to occupant needs for comfort and IEQ and using Engineering controls for indoor air quality (IAQ). Figure15

Figure **15** Adaptive and Responsive Systems for Psychological & Physiological Comfort

CONCLUSION

Research has consistently demonstrated that various (IEQ) factors can significantly influence psychological & physiological comfort and cognitive functions, such as attention, concentration, memory, and decision-making. Clarification of these impacts is vital for understanding the broader significance of (IEQ) through:

- Indoor Air Quality and Cognition → Elevated levels of CO2, VOCs, and particulate matter have been linked to reduced cognitive performance. Studies have shown that even moderate increases in CO2 concentrations, commonly found in poorly ventilated indoor spaces, can impair decision-making and concentration. Exposure to VOCs, often emitted from building materials and furnishings, can also negatively affect cognitive functions. The essence of IAQ's impact on cognition lies in its direct effect on brain function.
- Thermal Comfort and Cognitive Performance → Both excessively hot and cold temperatures can impair cognitive performance. Research suggests that optimal thermal comfort ranges exist for maximizing cognitive function, and deviations from these ranges can lead to decreased attention and increased errors. Thermal stress, whether from heat or cold, diverts resources away from cognitive tasks. The denotation of thermal comfort extends beyond physical sensation to include cognitive efficiency.
- Lighting and Cognitive Function → Exposure to natural daylight and well-designed artificial lighting has been shown to improve cognitive performance, particularly attention and reaction time. Circadian lighting, which mimics the natural light cycle, can positively influence alertness and cognitive function throughout the day. Poor lighting, conversely, can lead to eye strain, fatigue, and reduced cognitive performance. The intention of lighting design in cognitive contexts is to optimize alertness and visual processing.
- Acoustics and Cognitive Performance → Noise pollution and poor acoustics are well-documented detractors of cognitive performance. Background noise, especially speech, can interfere with concentration and memory. Acoustic design that minimizes distractions and promotes speech clarity is crucial for learning and working environments. The import of acoustics in cognitive settings is to minimize auditory interference and maximize focus.

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