ARTIFICIAL INTELLIGENCE AIDED BUILDING DESIGN AS THE DETERMINANT OF EFFECTIVE THERMAL COMFORT IN HOUSES. AN ACADEMIC DISCOURSE BY ARCHITECTS IN TERTIARY INSTITUTIONS IN AKWA IBOM STATE

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ABSTRACT

This study examined artificial intelligence-aided building design as the determinant of effective thermal comfort in houses, as an academic discourse. The integration of artificial intelligence (AI) into architectural design has revolutionised the construction industry, particularly in optimising thermal comfort in residential buildings. In the context of carrying out this research, the following subheads were expounded on: the concept of artificial intelligence, the concept of artificial intelligence-aided building design (AIAD) and the concept of thermal comfort. The study mentioned the features of thermal comfort in houses to include temperature regulation, humidity control and air movement/ventilation. The effect of AIAD on thermal comfort in houses, as mentioned in the study, included AI-optimised HVAC systems, AI-controlled shading devices and adaptive building envelopes, to mention a few. AI-driven design optimisation for sustainability, generative AI in built environment planning and integration of AI with building information modelling (BIM), among many others, were mentioned as the strategic ways of adopting AI to develop building design. The study concluded that AI-aided architectural design is transforming residential buildings by optimising thermal comfort and energy efficiency. One of the recommendations made was that architects and engineers should integrate AI-driven simulations and predictive analytics with sustainable building practices.

KEYWORDS: Artificial Intelligence, AI-Aided Building Design, Thermal Comfort and Houses

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INTRODUCTION

The integration of artificial intelligence (AI) into architectural design has revolutionized the construction industry, particularly in optimizing thermal comfort in residential buildings. As climate change continues to affect global temperatures, architects and engineers face the challenge of designing energy-efficient and comfortable living spaces. AI technologies, including machine learning algorithms and computational simulations, offer innovative solutions for improving thermal comfort while reducing energy consumption (Boutahri and Tilioua, 2024). These intelligent systems analyze vast datasets, simulate different climatic conditions, and propose design modifications that enhance indoor temperature regulation, ventilation, and insulation.

Thermal comfort, a crucial factor in housing design, refers to the state in which occupants feel neither too hot nor too cold, influenced by environmental and personal factors such as air temperature, humidity, and metabolic rate (Zhao, Ji, Deng, Wang and Liu, 2024). Traditional methods of achieving thermal comfort rely on standardized heating, ventilation, and air conditioning (HVAC) systems, which often lead to excessive energy consumption. AI-aided design introduces predictive analytics, smart control systems, and adaptive building materials to optimize thermal conditions dynamically. For instance, AI-driven simulations can evaluate window placement, building orientation, and material selection to enhance passive cooling and heating strategies (Manmatharasan, Bitsuamlak and Grolinger 2025).

The application of AI in architectural design goes beyond energy efficiency; it also contributes to sustainability by minimizing the carbon footprint of residential buildings. By leveraging AI, architects can create data-driven models that predict thermal behavior under various climatic scenarios, ensuring buildings remain comfortable throughout seasonal changes (Avci, 2025). AI-based tools, such as generative design software and computational fluid dynamics simulations, enable architects to explore multiple design alternatives rapidly, ultimately leading to more effective thermal comfort solutions. These technologies facilitate the creation of smart homes that automatically adjust internal conditions based on real-time weather data and occupant preferences.

Despite its potential, AI-aided building design faces challenges, including the high cost of implementation, the need for specialized expertise, and concerns over data privacy (Abioye, Oyedele, Akanbi, ... and Ahmed, 2021). Additionally, the effectiveness of AI in ensuring thermal comfort depends on accurate data collection and the integration of AI systems with traditional architectural practices. Some researchers argue that while AI enhances decision-making, human expertise remains indispensable in contextualizing AI-generated insights within the broader scope of architectural aesthetics and functionality (Hasan, 2024). The synergy between AI and human creativity is crucial in striking a balance between technological innovation and sustainable architectural design.

This academic discourse aims to explore the role of AI in enhancing thermal comfort in houses, examining its benefits, limitations, and future prospects. By analyzing case studies and existing literature, this study will provide insights into how AI-driven design methodologies can improve residential architecture. Additionally, it will assess the implications of AI adoption on construction practices, environmental sustainability, and occupant well-being.

Ultimately, the effectiveness of AI in achieving thermal comfort in homes is determined by its integration with architectural principles, environmental considerations, and emerging technological advancements. As AI continues to evolve, its potential to revolutionize building design and enhance thermal comfort in houses remains a promising area of research. This study will contribute to the ongoing discourse on AI-aided architecture, emphasizing the importance of intelligent design strategies in creating comfortable and energy-efficient homes.

CONCEPT OF ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is the study of how the human brain makes decisions, learns new things, and thinks through difficulties. According to Akpan and Essien (2025) Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. Adolf, Umo and Nkanta (2025) defined artificial intelligence (AI) as the study of how the human brain makes decisions, learns new things, and thinks through difficulties. A branch of computer science called artificial intelligence studies how computers learn, comprehend data, recognize characters in images, analyses pictures, and simulate how the eyes work (Udo-Okon and Akpan, 2024).

Furthermore, Lion and Ekefre (2024) the term artificial intelligence (AI) describes computer programmes that are able to carry out sophisticated operations that were previously limited to human performance, such as problem-solving, thinking, and decision-making. Artificial intelligence (AI), in its broadest sense, is intelligence exhibited by machines, particularly computer systems, as opposed to the natural intelligence of living beings. As a field of research in computer science focusing on the automation of intelligent behavior through machine learning, it develops and studies methods and software that enable machines to perceive their environment and take actions that maximize their chances of achieving defined goals, with the aim of performing tasks typically associated with human intelligence (Ikechukwu and Echerenachukwu, 2024).

Moreover, Akpan and Clark (2024) posited that artificial intelligence (AI) is the study of how the human brain makes decisions, learns new things, and thinks through difficulties. The goal of artificial intelligence is to enhance computer abilities related to human understanding, including language intelligence, learning, reasoning, and problem-solving. Also, Huge and Godwin (2024) stated that artificial intelligence (AI) is the idea and practice of creating computer systems that can do tasks like speech recognition, decision-making, and pattern recognition that traditionally needed human intelligence. Artificial Intelligence can be understood as the collection of technologies that enable machines to sense, comprehend, act, and perform several functions matching those of humans (Bassey and Owushi, 2023).

CONCEPT OF ARTIFICIAL INTELLIGENCE AIDED BUILDING DESIGN (AIAD)

Artificial Intelligence Aided Building Design (AIAD) refers to the integration of artificial intelligence (AI) technologies into the architectural, engineering, and construction (AEC) design processes. AIAD leverages machine learning, generative design, and computational intelligence to enhance building planning, optimisation, and automation. AIAD revolutionises traditional building design by improving accuracy, reducing costs, and enhancing efficiency through intelligent decision-making. AI's predictive analytics is transforming the landscape of healthcare by leveraging vast amounts of historical health data to forecast future outcomes (Godwin, Awofala and Oni, 2023). This prediction has helped in numerous ways to create designs capable of protecting human health.

Fig 1: Sample of AIAD

Source: https://www.e-zigurat.com/en/blog/ai-architecture-design-5-principles/

According to Cudzik and Radziszewski (2018), using artificial intelligence in architectural design is based on calculation and automation. Ao and Duan (2025) mentioned that artificial intelligence-aided design contains all design software offering various automated tools that support the creative process. AIAD enables design labour reduction; it employs AI to understand the mapping relationship between design variables and performance, then constructs an AI surrogate model to assist designers in assessing the impact of design variables on structural performance, effectively simplifying the evaluation process and avoiding design labour explosion in high-iteration situations. Hence, leveraging AIAD not only advances structural design towards greater efficiency and simplification but also streamlines the design workflow.

CONCEPT OF THERMAL COMFORT

Thermal comfort refers to the subjective state of mind expressing satisfaction with the thermal environment, encompassing factors like air temperature, humidity, air speed, and clothing, influencing whether someone feels too hot or too cold. According to Usanga and Isaac (2024) Thermal comfort is a state of mind that expresses satisfaction with the surrounding environment. It is influenced by a range of environmental and personal factors and is a critical consideration in the design and operation of buildings, particularly in heating, ventilation, and air conditioning (HVAC) systems. Understanding thermal comfort involves considering how different variables interact to create a subjective sense of comfort or discomfort. Thermal comfort means feeling comfortable in an interior space which directly impacts people's mood.

Furthermore, Olurotimi and Mfon (2023) mentioned that thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation. Thermal comfort describes the human satisfactory perception of the thermal environment. It refers to a number of conditions in which the majority of people feel comfortable. Thermal comfort describes the human satisfactory perception of the thermal environment. It refers to a number of conditions in which the majority of people feel comfortable. According to Budaiwa (2006) cited in Ekanem and Akwaowo (2016), thermal comfort is attained when a thermal balance is achieved: a situation in which no heat storage occurs in the body.

FEATURES OF THERMAL COMFORT IN HOUSES

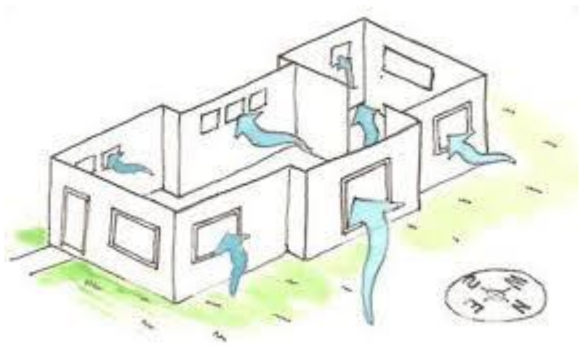
Thermal comfort in homes is influenced by multiple factors, including temperature regulation, humidity control, air movement, insulation, ventilation, and psychological adaptation. These features work together to create an optimal living environment that minimises discomfort and enhances energy efficiency. Below, each key feature is explained in detail:

Temperature Regulation: Temperature regulation is the primary factor affecting thermal comfort in homes. The human body functions optimally within a specific temperature range, typically between 18°C and 24°C (64°F to 75°F). Effective temperature control is achieved through heating and cooling systems, passive design strategies, and the use of thermal mass materials that absorb and release heat slowly. Smart thermostats and climate control systems enhance this regulation by automatically adjusting indoor temperatures based on real-time weather conditions and occupant behaviour (Abdel-Salam, 2021).

Humidity Control: Humidity plays a crucial role in thermal comfort, as it affects the body's ability to release heat through perspiration. The ideal indoor relative humidity for comfort is between 40% and 60%. High humidity levels can make warm temperatures feel hotter by reducing the effectiveness of sweating, leading to discomfort and potential health issues such as mould growth and respiratory problems. Conversely, low humidity can cause dry skin, throat irritation, and increased static electricity.

Air Movement and Ventilation: Air movement influences the perception of temperature and enhances thermal comfort by promoting heat dissipation from the body. Proper ventilation—whether natural or mechanical—ensures fresh air circulation, removing excess heat and indoor pollutants. Cross-ventilation, achieved through strategically placed windows and openings, facilitates effective cooling in warm climates. Ceiling fans, exhaust fans, and HVAC systems also contribute to maintaining air quality and temperature balance.

Fig 2: Image of Air Movement and Ventilation



Source: https://www.building.govt.nz/getting-started/smarter-homes-guides/air-quality-moisture-and-ventilation/passive-ventilation

Insulation Efficiency: Insulation is essential for reducing heat transfer between indoor and outdoor environments, maintaining a stable indoor temperature throughout the year. Well-insulated homes minimize heat loss in winter and prevent heat gain in summer, reducing reliance on artificial heating and cooling systems (Ren, 2022). Common insulation materials include fiberglass, foam boards, cellulose, and phase-change materials (PCMs), which store and release thermal energy.

Adaptive Clothing and Thermal Perception: The way individuals perceive thermal comfort varies based on personal habits, clothing choices, and cultural expectations. People adapt to temperature fluctuations by adjusting their clothing layers, which helps regulate body temperature effectively. For instance, wearing light and breathable fabrics in hot conditions enhances cooling, while layering clothes in cold environments provides warmth.

Radiant Heat Control: Radiant heat exchange affects how heat is absorbed or emitted by surfaces within a home. Heat radiation from walls, floors, ceilings, and windows can significantly impact indoor comfort. For example, dark-colored surfaces absorb more heat, making rooms feel warmer, while reflective or light-colored materials reduce heat absorption. Low-emissivity (Low-E) glass windows and thermal mass materials help regulate radiant heat, preventing excessive heat buildup indoors.

Smart Climate Control and Automation: Technological advancements in smart home automation have revolutionized thermal comfort management. AI-powered HVAC systems, IoT-enabled thermostats, and sensor-based climate control systems optimize temperature, humidity, and airflow based on real-time user preferences. These systems learn occupant behavior and adjust settings accordingly, ensuring an energy-efficient and comfortable indoor environment.

Fig 3: AI-powered HVAC Systems

Source: https://www.hehellc.com/automated-climate-control/

EFFECT OF AI AIDED BUILDING DESIGN ON THERMAL COMFORT IN HOUSES

Integrating Artificial Intelligence (AI) into building design has significantly enhanced thermal comfort in residential spaces by enabling dynamic and responsive environmental control systems (Ogundiran, Asadi & Gameiro da Silva 2024). The following are the effects that artificial intelligence has on assisting in building design to ensure thermal comfort:

AI-Optimised HVAC Systems: AI technologies have revolutionised HVAC system management by analysing data from sensors that monitor temperature, humidity, occupancy patterns, and external weather conditions. These systems can predict and adjust indoor climates proactively, ensuring consistent thermal comfort while reducing energy consumption. For instance, BrainBox AI's implementation in a Manhattan office building led to a 15.8% reduction in HVAC energy use, resulting in annual savings of over $42,000 and a decrease of 37 metric tonnes in carbon dioxide emissions. This proactive adjustment to temperature changes also enhanced tenant comfort (Ahsan, Shahzad & Arif 2024).

AI-Controlled Shading Devices: In regions with hot and arid climates, AI-controlled shading systems have proven effective in maintaining indoor thermal comfort. A study conducted in Egypt demonstrated that such systems could lower indoor temperatures by up to 4°C and reduce energy consumption by 25%. Additionally, occupant complaints regarding thermal discomfort decreased by 77.78%, and issues related to glare were reduced by 76%. These systems dynamically adjust shading based on real-time environmental data, optimising both thermal and visual comfort.

Adaptive Building Envelopes: AI facilitates the development of adaptive building envelopes that respond to changing environmental conditions. Smart materials and surfaces, such as electrochromic windows or dynamic insulation, can automatically adjust their properties based on AI analysis, maximising insulation efficiency and maintaining thermal comfort (Anber, 2024).

STRATEGIC WAYS OF ADOPTING AI TO DEVELOP BUILDING DESIGN

Integrating Artificial Intelligence (AI) into building design has emerged as a transformative approach to enhance efficiency, sustainability, and innovation in architecture. The following are the strategic ways to adopt artificial intelligence to develop building designs:

AI-Driven Design Optimisation for Sustainability: Implementing AI techniques, such as machine learning algorithms, can optimise building designs to achieve sustainability goals. Surrogate models, for instance, enable rapid evaluation of design alternatives, facilitating energy efficiency and environmental performance enhancements. A study carried out by Song, Wang, Chen, Zhang & Li (2025) highlighted that artificial intelligence is essential in surrogate-assisted design optimisation, emphasising its potential to streamline the design process and improve sustainability outcomes.

Generative AI in Built Environment Planning: Generative AI approaches, particularly deep learning models, can automate and innovate aspects of site layout, interior, and exterior design. These models can generate design alternatives based on specified parameters, allowing architects to explore a broader design space efficiently (Ahmed, Zhang, & Wang, 2024).

Integration of AI with Building Information Modelling (BIM): Combining AI with BIM enhances data management and decision-making processes throughout a building's lifecycle. AI algorithms can analyse BIM data to predict project outcomes, optimise resource allocation, and identify potential issues early in the design phase (Chen, Yu, Zhou, & Sun, 2024).

Machine Learning for Smart Housing and Interior Design: According to Gupta, Singh & Verma (2024), applying machine learning techniques in urban planning and interior design can lead to the development of smart housing solutions. These technologies enable the analysis of user preferences and behaviours, facilitating personalised and adaptive design solutions that enhance occupant comfort and energy efficiency.

AI for Energy Consumption Optimisation: Furthermore, Wang, Patel & Liu (2024) mentioned that utilising artificial intelligence to optimise energy consumption involves the application of algorithms that can predict and manage energy use in buildings. This includes optimising building orientation, window-to-wall ratios, insulation, and HVAC systems. A review discusses how AI can enhance architectural design efficiency by optimising building energy consumption through various strategies and technologies.

Surrogate Modelling for Building Performance Evaluation: Surrogate models serve as efficient approximations of complex simulations, allowing for rapid assessment of building performance under various design scenarios. These models are particularly useful in the early design stages to evaluate factors like energy use, delighting, and thermal comfort. A systematic review delves into the application of surrogate models in sustainable building design optimisation, discussing methodologies and identifying future research directions.

CONCLUSION

AI-aided architectural design is transforming residential buildings by optimising thermal comfort and energy efficiency. As climate change intensifies, architects leverage AI technologies like machine learning and simulations to enhance indoor temperature regulation, ventilation, and insulation. AI-driven design also promoates sustainability by reducing energy consumption and carbon footprints. However, challenges such as high costs, expertise requirements, and data privacy concerns persist. Despite these obstacles, the synergy between AI and human creativity remains essential. As AI continues to evolve, its role in designing intelligent, adaptive, and comfortable homes will be crucial in shaping the future of sustainable architecture.

RECOMMENDATIONS

1. Architects and engineers should integrate AI-driven simulations and predictive analytics with sustainable building practices. By optimising passive design strategies such as building orientation, material selection, and natural ventilation, AI can enhance thermal comfort while minimising reliance on energy-intensive HVAC systems.
2. Governments, universities, and industry stakeholders should invest in AI research and training programs to equip architects and engineers with the skills needed to implement AI-driven solutions.
3. The construction industry should prioritise the development of AI-powered smart homes capable of real-time thermal adjustments based on weather conditions and occupant behaviour.

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