



“ADVANCES AND INSIGHTS: A CRITICAL REVIEW OF POST-OCCUPANCY EVALUATION TOWARDS INDOOR ENVIRONMENTAL QUALITY”

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ABSTRACT

The impact of indoor environments on the perception and satisfaction of a building's inhabitants is now attracting attention from researchers due to the relentless heat and extreme weather patterns in tropical countries. This is especially true in Malaysia, where the hot and stagnant air indoors augments the lack of circulation, leading to significant discomfort among building occupants. This phenomenon spurred the concept of indoor performance as one of the supporting elements toward the globe's advancing sustainable development, which in turn addresses the need to evaluate the satisfaction and acceptance of spaces among their users. Today, many individuals are increasingly concerned about the sustainability of their work and living environments. As people seek both comfort and functionality, developers dedicate their efforts to creating sustainable spaces that meet the demands of occupants. In this pursuit, post-occupancy evaluation (POE) has proven instrumental in examining indoor environments, providing nuanced insights into how these spaces impact everyday activities. This evaluation method has successfully equipped developers with feedback that informs the design of future buildings and renovations, ultimately enhancing occupant experience. This paper delves into a rich tapestry of past and current literature on post-occupancy evaluation, focusing on critical areas such as thermal comfort, air quality, lighting, Acoustics and Ventilation Concentration. Key research gaps were highlighted with a lack of standardised instruments and limited data. This paper also underscores the immense importance of POE, drawing from previous studies to illustrate how it serves as a powerful tool for improving indoor environments and ensuring they meet the needs of those who inhabit them.

Introduction

In recent years, growing concern about the quality of the indoor environment has escalated the importance of post-occupancy evaluation (POE), as a mechanism for assessing the performance of the operational building and its core facilities. There has been a significant increase in research in this area (POE) since 2020, particularly in case studies, systematic reviews, and innovative methodologies. This review of the extant literature examines old studies published up to the most recent 2025, focusing on POE applications that address key aspects of the indoor environment, including thermal comfort, indoor air quality, acoustic comfort, lighting, productivity, and wellbeing. Post-Occupancy Evaluation (POE) is a critical process in assessing the performance of buildings after they have been occupied, focusing on various performance metrics to understand how well they meet the intended design objectives and occupant needs. A critical aspect of POE is the evaluation of Indoor Environmental Quality (IEQ), which encompasses factors like thermal comfort, indoor air quality, lighting, and acoustics (Elsayed et al, 2023). A building achieves the status of a true sanctuary when it successfully caters to the diverse needs of its occupants, enveloping them in an environment that fosters both comfort and contentment. The significance of a pleasant indoor atmosphere cannot be overstated; it is a fundamental right of every individual to relish such spaces. When indoor conditions falter, be it in active office settings or cosy residences, the repercussions can detrimentally affect both productivity and personal well-being, leaving individuals feeling uneasy and unmotivated. In light of these challenges, a dynamic wave of researchers is passionately dedicated to crafting sustainable indoor environments. Their goal is to cultivate spaces that not only enhance occupant comfort but also elevate the overall quality of life, transforming the way we experience our daily surroundings. Over the years, there has been a scientific concern in finding a relationship between indoor parameters and the view of a healthy living space and health for occupants to live effectively. There have been several surveys that target individuals to analyse the indoor comfort and how occupants react to the changes of their indoor environment (Nicol and McCartney, 2000; Leaman and Bordass, 2001). Zhao et al (2024) undertook a review study from 2000 to 2023 evaluating feedback on occupant thermal comfort and efficiency of energy in the building. It was affirmed that continued investigation needs to be embarked on, especially for those aspects that have limited information in terms of how building indoor space serves the occupants and improves their productivity.

Overview of POE Practices

Old and recent literature up to 2025 highlights various methodologies and practices of POE, findings, and challenges associated with POE in different buildings in residential and office settings. There is a lot of variation in POE protocols, and no one standard method is being used widely. Researchers often use questionnaires to collect feedback from occupants, usually based on existing survey designs. About one-third of the studies looked at productivity or performance, mostly using self-reported assessments. The study found challenges in evaluating performance, applying findings in real life, and conducting cost-benefit analyses (Dam-Krogh et al, 2024). In the context of residential buildings, a systematic literature review by Elsayed et al. (2023) examined POE practices over a decade. The study highlighted inconsistencies in reporting methods, tools, and data collection, making comparability and replicability challenging. The authors proposed a roadmap for more consistent POE approaches in residential settings to enhance occupant satisfaction and Internal Environmental Quality (IEQ). Lolli et al. (2022), in an attempt to analyse the application of POE in improving IEQ, found out the importance of occupant feedback in identifying discrepancies between designed and actual building performance. It also emphasised the need for both qualitative and quantitative assessments to capture the multifaceted nature of IEQ and occupant comfort.

A survey in Germany that was done in 17 German office buildings that emphasised of passive cooling concept, and this study represents a thorough analysis of occupant satisfaction and thermal comfort. According to the performance with a distinctive focus on the overall satisfaction of occupants by only one institute in one country, the boundary conditions for every consistent dataset were probably better, and the study will serve as a good example for more future investigations (Roulet et al., 2006). It is also considered that the Well-being and productivity of occupants may be affected and disturbed due to the poor living environmental conditions. Post Occupancy Evaluation (POE), which has been proven to be one of the effective strategies in terms of analysing the sustainability of a building after occupancy. Zimring and Reizenstein, (1980) defined POE as an operational examination of effectiveness for the human user of the occupied design environment, and it has been used in the past to investigate the environment to gain a profound understanding and impact on occupants in a building and its environment. Under post-occupants evaluation, standards and guidelines have been tailored to evaluate 20 different office buildings for future application (Joon-Ho et al, 2012)

In a comprehensive study done by Lolli et al (2022), they applied several elements in analysing and assessing several parameters of POE, including Functional Performance Elements, Behavioural Performance Elements, Technical Performance Elements, IEQ Parameters Assessed, and Assessment Methods.

Functional Performance Elements

Functional performance elements pertain to the efficiency and suitability of building components, including accessibility, spatial configurations, and service adequacy. Approximately 82% in a review done by Lolli et al (2022), investigated these elements, emphasising their significance in assessing occupant satisfaction and overall building performance.

Behavioural Performance Elements

These elements focus on the interaction between occupants and the physical environment, such as how space utilisation and design influence occupant behaviour and well-being. Around 77% of the studies reviewed by Lolli et al (2022), examined behavioural aspects, underscoring the importance of aligning building design with occupant activities and preferences.

Technical Performance Elements

Technical performance elements involve factors that directly impact occupant comfort, health, and productivity, including hygiene standards and various IEQ parameters. Approximately 78% of the studies addressed technical performance, reflecting a strong emphasis on creating environments that support occupant well-being.

Indoor Environmental Quality (IEQ) Parameters Assessed

The interaction between IEQ and occupant satisfaction is complex, with both physical and non-physical factors playing roles. Physical factors include measurable parameters like thermal comfort, indoor air quality, lighting, and acoustics, while non-physical factors encompass aspects such as spatial layout, privacy, cleanliness, and views. Notably, the findings from Lolli et al (2022) considered IEQ parameters to understand occupant satisfaction and inform potential improvements for future designers.

Methods and Instruments for POE

In recent years, a significant number of contemporary Post-Occupancy Evaluations (POEs) have increasingly adopted mixed-method approaches that integrate both subjective and objective data. Subjective insights are commonly obtained through occupant surveys, while objective data are collected via situational sensors and environmental monitoring tools

(Bae et al., 2021; Tang et al., 2020). This dual strategy mostly combines comprehensive questionnaires for occupants with exact measurements from environmental conditions such as temperature, humidity, air quality, and lighting levels.

A notable development in this context is the Sustainable Post-Occupancy Evaluation Survey (SPOES), which has gained prominence as a tool for assessing sustainability-related factors within the workplace (Bae et al., 2021). In Parallel, sector-specific instruments have been designed to address unique environmental and experiential dynamics (school settings). For instance, Cochran Hameen et al. (2020) introduced tailored evaluation tools for schools, aiming to capture the distinctive experiences of both staff and students in the learning environment.

Despite these methodological advances, a recurring challenge in POE research stems from the absence of a cohesive and standardised evaluation framework. Studies by Zhao et al. (2024) and Dam-Krogh et al. (2024) underscore important methodological inconsistencies across the literature, which limit the comparability and universality of the findings. This lack of standardisation highlights the urgent need for a unified framework that can cushion benchmarking, improve methodological rigour, and enable a more consistent understanding of POE outcomes across diverse contexts.

Assessment Methods

The methodologies employed in POE studies varied, with a significant portion (43%) incorporating in situ measurements of physical parameters, while 57% relied solely on qualitative assessments through occupant feedback. This variation highlights the diverse approaches in evaluating IEQ, ranging from objective measurements to subjective perceptions.

Benefits of POE

The benefits generated from the use of POE helps the researcher to identify successful design features as explained by Watson, (2003), Hewitt et al, (2005) in their study identify problems to moderate or reduce, improve building environment and performance, Information of the building's condition is achieved by reviewing what the occupants' feel and how they response to their needs (Vischer, 2002). In a study by Sekhar et al (2002), they pointed out that proper surveys and consultations with the building manager would offer additional information, which acts as the evaluation of the users of the building and a guide in solving problems that are related to the building's sustainability.

Thermal Comfort and Indoor Air Quality

The ability of a building to regulate the indoor environment to suit the occupant is important to the satisfaction of the occupant. Studies have proven that indoor air quality (IAQ) has a significant relationship with occupants and affects their performance in the overall indoor environment. IAQ has also been linked to one of the major environmental factors that can affect the occupants' health at their workplaces, causing mortality (Sundell, 2004). In an investigation by Young & Denise (2009), they found that occupants' performance can be influenced by indoor air quality and that it has a significant correlation with their general performance in their workspace. Thermal comfort evaluations often include measurements of temperature, relative humidity, and atmospheric pressure. For instance, studies have analysed thermal comfort in various building types, including green office buildings and university dormitories (Lolli et al. 2022).

Wagner et al, (2007) carried out a field study in Karlsruhe Germany campus with 14 offices with their windows facing north, two facing south having a natural ventilation and a laboratory building having mechanical ventilation because of its requirement for its workplace, it was noted their study that the office building is regarded as a low energy building with high heat insulating feature because Cooling is by external shading which reduces solar loads during a hot weather and Heat dissipation during summer is greatly enhanced by night ventilation which proves passive cooling to be highly effective. The result proves that a positive observation of thermal comfort is not limited to a sharp limit of the room temperature of about 20 C and the respondents voted "Just Right" for operative temperature higher than 27 C, which rates the indoor climate neutral and better with a vote up to 75%. This study exclusively shows that a naturally ventilated indoor space and passive cooling are appreciated in summer if the design is properly done in terms of the indoor climate. This research promotes the application of natural ventilation in office designs where the occupants of the said building produced a positive result in terms of thermal comfort. Indoor Air Quality (IAQ) parameters such as CO₂ levels, particulate matter (PM2.5), and formaldehyde concentrations are commonly measured to assess IAQ. Some studies have focused on CO₂ measurements as an air quality indicator in energy-certified buildings.

Another survey done by Leena & George, (2008) involved a Torrent Research Centre in Ahmedabad, India, using the "Building Use Studies Survey (BUS) Workplace Questionnaire". This research involves 6 laboratory and office blocks, and the total rating of temperature is significantly higher than the midpoint and benchmarks for the Passive Downdraft Evaporative Cooling buildings for Summer Mean =4.61, SD=2.1; Winter Mean=5.84, SD=1.2, for Air

conditioning in Summer Mean=4.44, SD=1.9; Winter Mean = 5.54, SD = 1.3. Having an overall comfort of Mean about 5.16, SD=1.6, which shows that the comfort condition of this indoor environment has not been compromised in case of temperature, air and Comfort for Passive Downdraft Evaporative Cooling. However, the response for Comfort and Ventilation from Passive Downdraft Evaporative Cooling and Air-conditioning was predominantly positive. Passive Downdraft Evaporative Cooling comments from the survey are "Satisfactory, well ventilated, Good infrastructure and good ventilation". They determined that the air-conditioned structure achieved slightly higher comfort satisfaction levels compared to the Passive Downdraft Evaporative Cooling building; however, when considering the "international benchmark and scale mid-point," the Passive Downdraft Evaporative Cooling consistently performed better.

Joon-Ho et al (2012) according to their findings on post-occupancy evaluation of 20 office buildings as basis for future indoor environment quality (IEQ) standards and guidelines under thermal satisfaction in different gender group and it was seen that more than 50% of the female participants were obvious less satisfied with their thermal environment more than the male folks during cold season between 23 C and 24 C, also it was discovered that there was no substantial measured difference in temperature between gender groups leaving influential explanation for variation in satisfaction in terms of different in clothing. They went further to prove that the difference in gender activity due to more desk activities of the female group. Based on these findings the suggested that future designers must provide designs with thermal condition that will guarantee equal satisfaction for both gender and there was no significant measured temperature difference between the thermally dissatisfied and thermally satisfied in the same gender.

Abbaszadeh et al (2006) studied on occupant satisfaction with indoor environment quality in green building and non-green building and the results shows that the occupants of green building were more satisfied with their thermal comfort in their workplace than the occupants in non-green building this was because of the design features of the green building that have to do with the use of green material, improved ventilation and letting the occupants have control over the windows. A similar outcome was observed in the research conducted by Warren & Peter (2008), which indicates that "thermal comfort affects the overall satisfaction with the indoor environment of a workplace. Occupants who felt warm during the summer rated their indoor environment as 'poor,' while those who felt cool rated it as average, and those who were comfortable with their indoor setting rated it as 'Good.' Clearly, the

relationship between thermal comfort and occupant satisfaction applies to both residential and workplace settings. This holds for both green and conventional buildings; thus, designing for satisfactory thermal conditions should be prioritised for occupant comfort, as it has been associated with improved performance. However, they noted that their data was limited and insufficient to definitively claim that green buildings provide greater comfort and satisfaction than conventional buildings in workplace environments. It is then very important to take into account that the prospect in the building sector hope on the rate at which occupant are satisfied with the indoor environment; this is to note that this issue is not only relevant to the new buildings but a lifespan problem which has to be taken seriously right from the early stage of investment also vital for developers to really understand and work towards the wants of their occupants (Ilesanmi, 2010).

Young & Denise, (2009) studied indoor environmental quality related to occupant satisfaction and performance in LEED-certifies building and they found also that thermal comfort (indoor environment quality) influences the occupants workspace (but without much difference in percentage of satisfaction and dissatisfaction) which gave an even distribution through the respondents, having a percentage of satisfaction 39 and dissatisfaction 4, and the percentage interfered with performance 36% and increase in performance 37% the result showed no much difference but with negative mean score. They advised from their findings that designers and the building sector should also be concerned with the provision of quality office furnishing to improve the performance and satisfaction of its occupants, instead of focusing only on the LEED standard, since this standard does not directly address the issue in this research.

Lightening

Lighting assessments of visual comfort and workplace productivity often involve measuring lighting levels. Studies have examined lighting conditions in office environments and their impact on occupants (Lolli et al, 2022). However, lightning is also a very significant issue in indoor environment quality, which has shown influence on the satisfaction and performance of occupants. These findings would help developers and building designers to take a positive stand towards achieving a satisfactory indoor quality. A building whose indoor environment quality fails to satisfy its occupants is said to affect the occupant's well-being and productivity (Leaman et al, 2007). In a survey by Cuttle, (1983) in New Zealand and England to study the perceived attributes of office windows, which involved 471 participants in an office building, they were asked if window was an important feature in their workplace and

99% of the participants felt that windows should be in an office, while 86% see daylight be their choice of indoor lighting. This is due to the belief that daylight will reduce stress at their workplace than working by electric light. However, it has been reported by many research works that the majority of occupants in the workspace believe that natural lighting is better than artificial light due to its effect on people. Christoffersen et al, (2000) reported on post-occupancy evaluation in both spring and fall of a 20 building this study involved 1823 participant of an office building who were giving the chance to express their view towards window and daylight and electric light in their workplace, but more than 70% were satisfied with daylight condition in the workplace, they also stated that most of the respondent had their electric light on at the same time as the daylight.

Nevertheless, in a study by Young & Denise, (2009) they stated that the *“majority of the respondents had a window within 15 feet facing north, but the most complaints regarding lightening quality were related to a low level of illuminance in their workspace”* meaning that the occupants in the building did not get adequate light, notwithstanding they had 15 feet window. These results provide further insights into the significance of light from particular directions and highlight the importance of the quality of natural light. Leena and George (2008) also studied two different building in India one having a passive downdraft evaporative cooling and the other an air-conditioned building, their findings prove that both buildings in overall lighting performance were satisfactory with both having comparable configuration of windows to wall ratio and access to natural light, Although some workspace did not receive natural light and this respondent comment that (those in PDEC) *“Natural light was insufficient”*; (those in AC) *“Lighting was very good”*.

Abbaszadeh et al (2006) compared lighting in green and non-green buildings, and the result shows that occupants in the green building were more dissatisfied with the level of lighting than the non-green building. The reason was that the people in this office do not have control over the lighting, windows and blinds. The common problem identified in their study was that the amount of light in LEED-rated/green building and the CBE database building (green and non-green building), although is also acceptable using daylight to save energy and enhance the indoor environment quality which will help promote the quality of indoor light and reduce energy consumption when using electricity but the control of this daylight in the indoor environment is seen limited to most occupants in this office as discussed earlier. Therefore, it is important to note that the lighting also affects the satisfaction of occupants, and they should be given control over operating windows in the office and employing daylight.

Acoustics

Another aspect is acoustics, which has to do with noise. Noise levels are evaluated to understand their influence on occupant satisfaction and productivity. Research has explored acoustic performance in various settings, including educational institutions and open-plan offices (Lolli et al, 2022, Silva & Costa, 2022; Tang et al., 2020).

Monitoring and Low-Cost Sensors

Since 2020, continuous sensor monitoring has become a key addition to POEs, enhancing traditional survey findings. Studies have applied thermal sensors in sports facilities considering climate change (Huang et al., 2022), assessed vegetation and indoor air quality in residential settings (Xu et al., 2024), and widely monitored CO₂ levels and particulate matter to evaluate ventilation and health risks (Burridge et al., 2020). The emergence of low-cost sensors has enabled longer monitoring campaigns, offering richer data and valuable seasonal insights into indoor environmental conditions.

Application in different types of Buildings

Post-occupancy evaluations (POEs) have been extensively utilised across a variety of building types to assess their performance and occupant satisfaction. In the realm of residential buildings, a comprehensive review by Zhao et al. (2024) and Elsayed et al. (2023) highlighted that, despite the implementation of advanced energy-efficiency upgrades—such as improved insulation, high-performance windows, and energy-efficient appliances—many families continue to report significant dissatisfaction regarding their thermal comfort and acoustic environments. This suggests a disconnect between energy efficiency measures and the actual lived experience of residents, pointing to a need for a more nuanced approach that integrates both energy performance and occupant comfort.

In the context of educational facilities, Cochran Hameen et al. (2020) established a vital relationship between indoor environmental quality (IEQ) and student academic performance. Their findings, reinforced by several case studies, highlighted persistent challenges associated with inadequate daylighting and poor ventilation. These issues appear to have an adverse effect on students' concentration, overall well-being, and productivity, thereby underscoring the need for design strategies that enhance access to natural light and ensure proper air quality in learning environments.

Similarly, in healthcare facilities, multiple studies conducted between 2020 to 2024 emphasised the importance of acoustic privacy and thermal stability. A serene and calm environment is important for patient recovery, while stable thermal conditions contribute not

only to patient comfort but also to effective control of infections. Generally, these findings highlight the critical need for healthcare settings to prioritise sound insulation and temperature regulation as primary elements of patient-centred care.

POEs within office environments have revealed diverse employee responses to the mixed work models that emerged in the aftermath of the COVID-19 pandemic (Dam-Krogh et al., 2024). While many employees value the adaptability and improved work-life balance afforded by these arrangements, others report challenges related to social isolation and reduced opportunities for collaboration. These difference underscores the importance of designing workplace environments and policies that actively promote engagement, inclusivity, and communication in hybrid contexts.

In leisure facilities and sports, esoteric studies such as Huang et al. (2022) identified unique ventilation requirements shaped by the dynamic nature of physical activities and fluctuating occupancy levels. Managing these challenges necessitates innovative ventilation solutions capable of adapting to changing conditions while maintaining the best indoor air quality for both athletes and spectators. These insights support the important role of POEs in guiding design innovations that respond to the operational demands of distinct building types.

Ventilation Concentration During Pandemic

The COVID-19 pandemic reframed the role of ventilation, elevating it from a background consideration in POEs to a more central determinant of health and safety. Burrige et al. (2020) improved this shift by developing systematic models that qualified infection risk through CO₂ levels, later demonstrating their applicability across varied environments such as schools, offices, and select healthcare facilities. Their research provided compelling evidence that effective ventilation is indispensable in reducing the risk of airborne transmission.

Furthermore, Tang et al. (2020) highlighted how occupant dissatisfaction with ventilation systems, alongside acoustic concerns, became especially pronounced during the pandemic. This finding underscored a wider truth: ventilation is not only a technical performance issue but also a critical factor, shaping user comfort and well-being. Such insights reveal how health-centric metrics in POE have become increasingly vital in our evaluations of built environments.

Subsequently, Lolli et al. (2022) argued for the institutionalisation of real-time indoor air quality (IAQ) monitoring within building management systems as a fundamental component of building management strategies in the post-pandemic landscape. They contended that continuous monitoring could strengthen infection control, redefine post-

pandemic standards and ultimately inform responsive building operations for healthier indoor environments.

Integration of Digital and BIM-Linked POEs

Recent advances in digital technology have generated growing interest in the development of digitally integrated POE systems. Artan et al. (2022), for instance, pioneered a Building Information Modelling (BIM)-integrated POE framework that spatially engineers occupant complaints within facilities. This approach not only provides a detailed visualisation of building-related issues but also enables more precise and efficient facility management interventions, as problems can be addressed according to their exact spatial context.

Building upon this trajectory, Lizana et al. (2024) proposed the “POE plus intervention” (POEI) protocol, which establishes a systematic connection between continuous monitoring of building performance and the immediate implementation of corrective measures. By integrating real-time data acquisition with proactive management strategies, the POEI framework advances the dual objectives of improving occupant satisfaction and optimising operational performance.

Generally, these emerging digital methodologies demonstrate the possibility of transforming POE from a largely diagnostic exercise into a dynamic management tool. By operationalising evaluation findings and linking them directly to actionable interventions, they serve as critical mechanisms for closing the gap between assessment and practice in the governance of built environments.

Outcomes on the Effect of Indoor Environmental Quality on Productivity and Wellbeing

Recent POEs have consistently demonstrated a unique association between Indoor Environmental Quality (IEQ) parameters and both occupant well-being and productivity. Bae et al. (2021), for instance, identified thermal that thermal comfort, defined as satisfaction with indoor temperature and humidity conditions, together with acoustic quality and air purity, as the most significant predictors of perceived productivity across a range of settings.

Complementing these findings, Xu et al. (2024) highlighted that the incorporation of indoor greenery exerts a positive influence on occupant well-being in residential environments. The integration of plants and other natural elements not only enhances the visual and aesthetic quality of spaces but also contributes to improved psychological health and a heightened sense of serenity.

Furthermore, research conducted by Tang et al. (2020) and Huang et al. (2022) has drawn attention to persistent dissatisfaction with lighting conditions and acoustic

environments across multiple building types. These recurring challenges show the imperative for architectural and design strategies that prioritise sound management and lighting quality as integral components of healthy, productive, and supportive indoor environments.

Systematic Reviews and Meta-Analyses

Recent systematic reviews by Lolli et al. (2022), Zhao et al. (2024), and Dam-Krogh et al. (2024) reveal that research on POE continues to be fragile and methodologically inconsistent. Although most POE studies have grown immensely, particularly in developed regions as Europe, North America, and East Asia. There remains a significant lack of contributions from developing countries. This difference raises critical concerns regarding the generalisability of findings across different socio-economic and cultural contexts.

The reviews also underscore a notable gap in longitudinal POE research that systematically tracks IEQ over extended periods and multiple seasons. The absence of consistent and long-term monitoring limits our comprehension of how dynamic environmental factors, including temperature fluctuations, air quality changes, and humidity variations, affect experience and well-being throughout the year. Insights derived from transverse research are essential for formulating design strategies and policy interventions capable of improving indoor environments for occupants globally, irrespective of geographic or economic differences.

Gaps and Future Research

The reviewed literature exposes persistent weaknesses in POE methodologies, the most persistent of which is the non-establishment of a workable standard. Despite the years of unrelenting research and practices. POE practices have continued to root into unstable tools ranging from ad hoc questionnaires to inconsistent reporting formats. This need for uniformity is underscored by recent studies conducted by Zhao et al. (2024) and Dam-Krogh et al. (2024), which indicate that without a cohesive approach, the comparability and reliability of POE results are compromised.

Secondly, despite advancements in sensor technology and system integration, a significant proportion of POEs continue to be conducted over relatively short timeframes. These limitations restrict the capacity to assess building performance across different seasons and extended periods. The lack of long-term performance data leaves critical aspects, such as patterns of energy consumption, overall building efficiency, and occupant comfort, largely explored.

Furthermore, the translation of POE findings into practical design refinements or effective building management strategies remains insufficient. As noted by Artan et al. (2022), the insights generated through evaluations often fail to reach practitioners who are best positioned to implement changes, thereby diminishing the potential impact and utility of POEs.

Finally, there exists a marked regional bias within the current body of POE research, with an overwhelming shift towards temperate climates. This neglect shows the need for more comprehensive studies in underrepresented regions, particularly in Africa and Central Asia, where specific climate and cultural contexts may yield alternative perspectives on building performance and occupant satisfaction. Addressing this bias is essential for developing a more global representation and inclusive understanding of the outcome of POE.

Conclusion

Post-occupancy evaluation have proved in past reviews to be exclusively relevant in terms of perceiving occupants perception towards their indoor environment quality both in their living space and in workspace and provide positive feedback for designers, builders and investors pointing out the very area in the building and the indoor environment to improve in such to suit its occupant comfort productivity and needs not only acting as a benchmark for solution for new buildings (indoor environment) but also to give knowledge on areas to be improved in an existing building (indoor environment). Post occupants' evaluation, as reviewed in the past literature, has linked occupant satisfaction, environmental conditions, so that investments would be made in areas that matter, so as to achieve sustainability would be achieved in the near term. From this paper, it is concluded that between 2020 and 2024, POE has advanced significantly through the integration of sensor-based monitoring, digital tools, and a renewed focus on ventilation in the wake of the COVID-19 pandemic. These innovations have enhanced the assessment of building performance and occupant satisfaction more effectively. However, several persistent challenges remain, including inconsistent methodologies across studies, a shortage of longitudinal data that tracks changes over time, and difficulties in translating research findings into practical applications.

Future research should therefore prioritise three key directions: the establishment of standardised frameworks that allow for cohesive evaluation approaches, the execution of longitudinal studies that provide comprehensive insights into building performance over time, and the establishment of mechanisms that ensure POE findings are effectively integrated into design, management, and policy practice.

From the literature review, it was observed that there is still a limitation of knowledge in thermal comfort, air quality and indoor lighting and satisfaction of occupants towards their

indoor quality between green buildings and non-green buildings, although the occupants were very satisfied with their indoor environment quality and comfort. Accordingly, it was seen that most of the studies were essentially done on a few buildings with the same kind of operation and design, which makes it difficult to generalise between the preference of satisfaction in their indoor quality between green buildings and non-green buildings. There was also a strong satisfaction with daylight from this review, which the occupants felt that daylight was better than the electric lighting, with reasons that improve workers' productivity and promote good health at the workplace. Finally, it is necessary to introduce a light redirecting blind to improve daylight view without glare and provide an integrated manual control for both lighting and shading.

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