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The Role of Post-Occupancy Evaluation in Improving the Office Building's Environment

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Khadija Elsayed Shakra[1]
Serif Mohamed Ali[2]
Magdy Mohamed Elnahas[3]
Heba Saeed Mahmoud[4]
Bahaa Elboshy[5]

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Abstract: Employee well-being and productivity are paramount in today's work environments. However, the impact of interior design on these factors in Egyptian engineering offices remains a mystery. This study bridges this knowledge gap through a post-occupancy evaluation (POE) approach, examining how various design elements influence occupant experiences and work outcomes in two selected buildings. The dearth of in-depth POE studies in Egypt necessitates a deeper exploration of the relationship between interior design and workplace performance. Visual relief, thermal comfort, indoor air quality, lighting design, and architectural style hold immense potential for optimizing office environments. Employing a meticulous POE methodology, the research gathers comprehensive data from building occupants through surveys, interviews, and thorough walkthrough evaluations. The study unveils nuanced insights into how interior design shapes workplace experiences by delving into occupant perceptions and preferences and physically assessing the workspace. Preliminary findings from the POE process suggest that architectural design significantly impacts visual relief and spatial comfort. The importance of natural light and proper ventilation in enhancing occupants' well-being and productivity is highlighted. These findings emphasize the crucial role of thoughtful interior design in fostering conducive work environments within Egyptian engineering offices. This research advocates for further POE studies to refine workplace design practices specific to this context.

1. **Introduction**

Buildings are designed to serve specific purposes and provide a comfortable environment for occupants. Ensuring the well-being and productivity of building occupants is a crucial goal

[1] Assistant Professor, Dept. of Arch. Construction Technology, Faculty of Technology and Education, Beni Suef University, Egypt. Khadija.Shakra@techedu.bsu.edu.eg
[2] Professor, Dept. of Civil and Arch. Construction Technology, Faculty of Technology and Education, Suez University, Egypt. osha_cal1960@yahoo.com
[3] Professor, Arch. Eng. Dept., Higher Institute of Engineering and Technology – Arish, Egypt. magdynahas@yahoo.com
[4] Master Student, Dept. of Civil and Arch. Construction Technology, Faculty of Technology and Education, Suez University, Egypt. heba.mael@ind.suezuni.edu.eg
[5] Associate Professor, Arch. Eng. Dept., Tanta University, Egypt. bahaa.elboshi@f-eng.tanta.edu.eg

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in architecture [1]. However, how well a building performs in real-world use often differs from expectations. While meticulous design aims to achieve this, a building's actual performance can sometimes fall short of expectations. Post-occupancy evaluation (POE) is a valuable tool to bridge this gap by assessing a building's performance after it's occupied [2].Direct user input is crucial for optimizing building design and function. Post-occupancy evaluation (POE), introduced in the 1960s, provides a framework to gather this feedback [3]. POE is a systematic process conducted after a building has been occupied for some time. It's not simply about checking if the building looks good; it's a deep dive into its performance across three key dimensions: functional, technical, and behavioral [4]. The functional dimension assesses whether the space allocation, accessibility features, and overall layout truly support the intended use. [2]. POE goes beyond simply examining a building's features; it delves into how occupants experience the space [5]. POE captures their needs, challenges, and satisfaction with the built environment by directly involving users through surveys, interviews, and in-building visits. [3], [5], [6]. This user-centric approach allows for a crucial "post-dwelling" evaluation, revealing discrepancies between the envisioned design performance and the reality of everyday use. POE can pinpoint shortcomings in design, construction, or even user behaviour, ultimately informing targeted improvements for future buildings [4], [7].

POE doesn't just focus on user experience; it examines a building's overall performance, including critical factors like thermal comfort, lighting, and acoustics, which directly impact occupant well-being and productivity [3]. POE also considers building automation systems, the technology that regulates lighting, air conditioning, and other functions [5]. By analyzing how effectively these systems operate and contribute to a comfortable internal environment, POE can identify areas for improvement in both user experience and building efficiency [5]. POE utilizes a variety of data collection methods to gain a holistic understanding. Standardized questionnaires gather occupant feedback on everything from thermal comfort to noise levels. In-depth interviews delve deeper into user experiences, satisfaction levels, and suggestions for improvement [7]. Researchers might even directly observe how occupants utilize different workspaces, identifying areas of underutilization or potential conflicts. Specialized equipment measures objective data on indoor environmental quality (IEQ) parameters like temperature, humidity, and $CO2$ concentration [8], [9].

Modern office spaces are designed to be more than just places to work; they are intended to foster productivity, well-being, and collaboration among employees. However, achieving these goals requires a scientific understanding of how occupants interact with the built environment. [10], [11]. Consequently, the office building evaluation becomes crucial, particularly POE. Imagine an office designed for open collaboration but filled with tiny, closed-off cubicles – a POE would reveal this mismatch. [2]. The technical dimension focuses on the effectiveness of building systems. Are the lighting and ventilation systems maintaining a comfortable and healthy indoor environment? Does excessive noise from outside traffic disrupt concentration? Finally, the behavioural dimension explores the relationship between physical space and how people use it. [12]. Do the workspaces encourage collaboration or isolate employees? Is there a mismatch between the types of tasks performed and the available space? [10], [11]. By employing a scientific approach to office building evaluation, stakeholders gain valuable insights that can be used to improve employee well-being and productivity. Understanding how the physical environment impacts occupant health, comfort, and focus allows for targeted improvements [2], [10]. For example, a POE might reveal that poor ventilation leads to headaches and fatigue among employees, prompting the installation of an improved ventilation system [7]. Data on energy consumption and space utilization can also inform strategies for resource management. Imagine an office where half the desks are consistently empty – a POE could identify opportunities for space optimization, potentially leading to cost savings through downsizing or better space allocation [13], [14]. Ultimately, POE findings can guide future office design decisions and inform building automation systems for optimized performance. Imagine an office building that learns and adapts; a POE might reveal that employees prefer cooler temperatures in the morning and warmer temperatures in the afternoon, prompting the building automation system to adjust heating and cooling accordingly [14].

The implementation of POE is accompanied by challenges. Ensuring robust data collection and overcoming the knowledge gap between researchers and practitioners requires careful planning and collaboration [15]. However, future research directions offer promising solutions. Standardizing POE methods will facilitate comparisons across different office buildings, allowing for broader insights. [10], [16]. Long-term studies can assess the long-term impact of design alterations on occupant well-being and productivity, providing valuable data for future projects. Integrating POE data with Building Information Modeling (BIM) systems can create a dynamic feedback loop for continuous improvement throughout a building's life cycle. Imagine a BIM model incorporating user experience data, allowing designers to test and refine office layouts before construction begins. By adopting a scientific approach to office building evaluation, we can create aesthetically pleasing workspaces that enhance employee experience and, ultimately, organizational success. In today's competitive landscape, a well-designed and well-evaluated office space can be a significant differentiator, attracting and retaining top talent and fostering a culture of innovation and productivity.

A wealth of research underscores the critical role of Post-Occupancy Evaluation (POE) in office design. Studies have explored how POE is applied in various settings, demonstrating its effectiveness as both a research tool and a method to enhance building functionality in residential and commercial spaces [3]. This research provides a strong foundation for applying POE to optimize office environments. The research in [3] analyzes over 146 POE projects completed since 2010. This large-scale analysis establishes valuable qualitative and quantitative benchmarks for evaluating office building performance using POE. Highlighting the versatility of POE, Giuli et al. critically review recent case studies of green building certification programs like LEED and BREEAM. This review emphasizes how POE can complement these programs by providing user-centric insights into occupant experience and building performance beyond traditional certification metrics [17]. Ilter et al. focus on the metrics and methods used within POE tools to assess occupant satisfaction [18]. Understanding how POE measures satisfaction is crucial for designing offices that promote well-being and productivity. Recognizing the indoor environment's significant impact on occupants, Esfandiari et al. explored key IEQ parameters like air quality, thermal comfort, acoustics, and lighting [19]. These studies inform the development of POE methods that effectively evaluate these critical office design aspects.

Amidst a wealth of global research on Post-Occupancy Evaluation (POE), Egypt's architectural scene notably lacks such studies, a gap of concern amidst the nation's ongoing urban transformation [8]. As Egypt's cities undergo significant changes, integrating POE methodologies becomes imperative to ensure that office buildings effectively serve occupants and contribute to organizational prosperity [20]. This research endeavours to fill this void by delving into the potential of POE within the Egyptian context. Its broad objectives cover occupant experience, Indoor Environmental Quality (IEQ), productivity, building design, management, and user behaviour within office settings. The research aims to lay the groundwork for broader POE adoption in Egypt by tackling these objectives. Ultimately, this initiative seeks to cultivate office environments that boast aesthetic appeal and foster employee well-being and organizational advancement, propelling Egypt's architectural evolution forward. This paper focuses explicitly on applying POE in evaluating Indoor Environmental Quality (IEQ) within administrative buildings. IEQ encompasses various factors like thermal comfort, lighting, and acoustics, significantly impacting occupant health, satisfaction, and productivity. This review analyzes how POE methodologies integrate these IEQ parameters. By examining how POE captures user experience and satisfaction with these environmental factors, we can gain valuable insights to improve future building design and management practices in administrative settings.

2. Methodology

This research uses a mixed-method approach that combines descriptive and analytical methods to conduct a Post-Occupancy Evaluation (POE) of the internal environment of engineering office buildings in Egypt. The study began with a descriptive analysis of the current use of automation systems in office buildings, as shown in Figure 1. Two office buildings were selected as case studies: one with an automation system and one without. Each building was evaluated individually to understand the specific impacts of its respective conditions. A comprehensive POE questionnaire targeted at building occupants was used to assess key factors: internal environment quality (visual comfort, thermal comfort, indoor air quality, and acoustics), user satisfaction (personal control and problem resolution), work productivity (impact of the environment on productivity), and architectural design (development, security, accessibility, and technology). The questionnaire was administered online and on paper, with responses primarily collected via Likert-scale questions to facilitate quantitative analysis.

To gather data for this Post-Occupancy Evaluation, a purposive sampling strategy was employed. Participants were selected from employees actively working in the two case-study office buildings: Dar Al-Handasah Smart Village Offices (Building A) and The Arab Office for Engineering Designs and Consultations (Building B). For each building, 20 employees were recruited to participate in the study, resulting in a total sample size of 40 respondents. The selection criteria aimed to include a diverse range of roles and responsibilities within the engineering office context. This included, but was not limited to, engineers, architects, administrative staff, and mid-level managers, representing various departments to ensure a comprehensive spectrum of user experiences and satisfaction levels was captured. All participants were employees who regularly worked within the respective buildings. Their responses to surveys and interviews formed the primary data for evaluating the office environment. While this targeted sample provides in-depth qualitative and quantitative data specific to these two engineering offices, it is important to acknowledge that the generalizability of the findings to a broader population of office buildings, or to different types of organizations in Egypt, may be limited due to the specific nature of the selected case studies and the modest sample size.

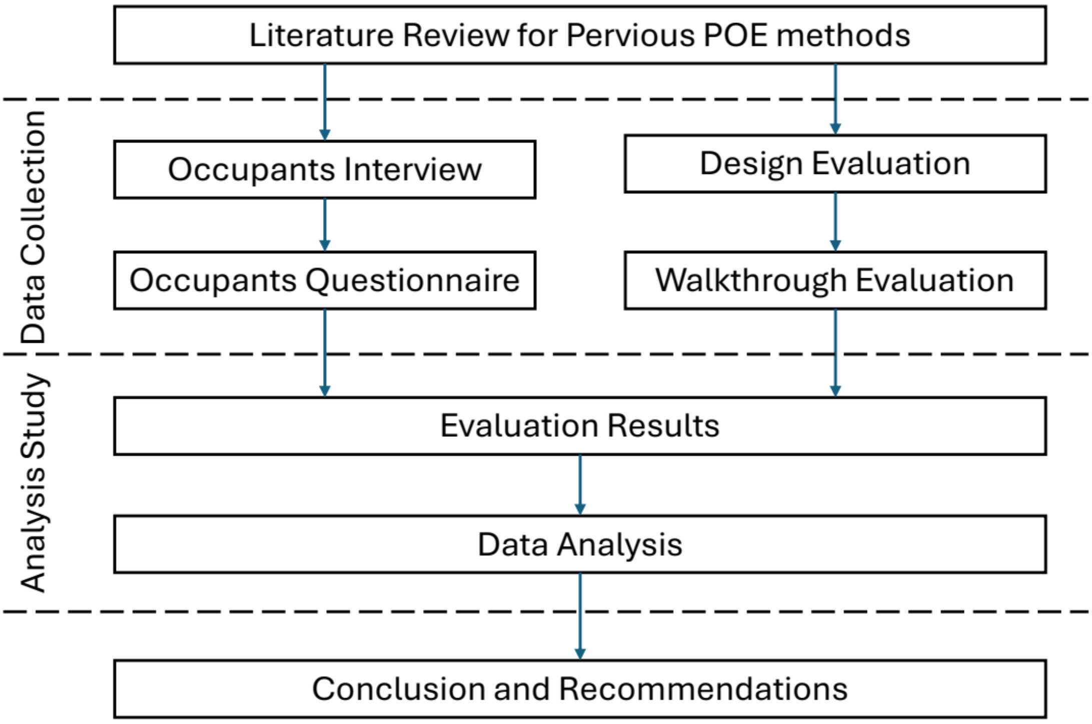


Fig. 1. Research Methodology Flowchart

Occupants from both buildings participated, ensuring a representative mix of roles and positions to capture comprehensive user experiences and satisfaction levels. The responses were analyzed individually to isolate the specific impacts of the automation system. The analysis focused on indoor environment quality, user satisfaction, work productivity, and architectural design. Key POE identifiers, including the research objective, case study details, data collection methods, specific data collected, monitoring specifics, research approach, and data analysis methods, were examined. This methodological approach provided valuable insights into how different conditions influence the performance of engineering office buildings in Egypt, aiming to inform future building designs and enhance user satisfaction and productivity through improved internal environments. The research offers a broader understanding of post-occupancy performance by including automated and non-automated buildings. Quantitative data collected from the questionnaires, particularly from the Likert-scale responses, were analyzed using Microsoft Excel. This software was employed for organizing raw data, calculating descriptive statistics such as frequencies, percentages, and mean scores for various satisfaction and perception metrics. Excel was also utilized for the generation of the charts and graphs presented in the results section to visually represent these findings and facilitate comparisons between the two case study buildings.

Unlike many global POE studies that assess single buildings or similar types, this research adopts a comparative mixed-methods approach, evaluating two engineering office buildings in Egypt with differing levels of automation. This contrast enables a nuanced analysis of technology's impact on indoor environmental quality (IEQ) and occupant satisfaction. Additionally, the focus on engineering offices—a specialized sector with distinct spatial and functional demands—sets this study apart from the broader POE literature, which often targets generic office spaces or other building typologies.

2.1. POE Element Selection

The selection of elements for Post-Occupancy Evaluation (POE) was guided by a thorough review of existing literature on building performance and occupant satisfaction. Several key sources were examined to identify the most relevant and impactful factors that influence the success of office environments. This literature review provided a foundation for defining the specific elements to be included in the POE for this study. Literature consistently highlights the importance of evaluating multiple dimensions of building performance to understand how well a building serves its occupants. These dimensions include functional, technical, and behavioural aspects, offering a holistic view of building performance. Reviewing numerous studies, we identified the most critical elements within each dimension. One critical dimension is Internal Environment Quality (IEQ), which encompasses visual Comfort, Thermal Comfort, ventilation, and air quality. Questions in the questionnaire addressed these aspects, such as the adequacy of natural and artificial lighting, feelings of warmth from sunlight, ventilation suitability, and satisfaction with humidity levels and indoor air movement. These elements were selected based on research demonstrating their impact on occupant comfort and productivity [17], [20].

User satisfaction is another crucial dimension, focusing on how well the building meets occupants' needs and preferences. Questions in the questionnaire assessed personal control over the environment, Comfort of office spaces, satisfaction with workspace layouts, and overall sense of belonging. These aspects were chosen to align with findings emphasizing the importance of personal control and comfort in promoting occupant satisfaction [14], [21]. The physical environment directly influences work productivity, making evaluating factors related to workspace layout and functionality essential. Questions in the questionnaire explored the suitability of distances between colleagues, changes in room layouts, and the adequacy of desk spacing, all known to impact productivity levels [22], [23]. Architectural design plays a significant role in shaping the functionality and appeal of office spaces. Questions in the questionnaire examined building and workspace modifications, satisfaction with the building facade and street views, and the aesthetic and functional design of the workspace. These elements were selected to reflect the importance of adaptable and aesthetically pleasing environments in fostering positive work cultures [24].

3. Cases of the study

The research focuses on two distinct case studies chosen from engineering office buildings. One case represents a building with fully automated operations, while the other lacks automated operation systems. Both buildings share similarities in size and the number of employees they accommodate. This deliberate selection allows for a comparative analysis of the performance of buildings with and without automation, shedding light on the impact of automation systems on various aspects of building operation and occupant experience.

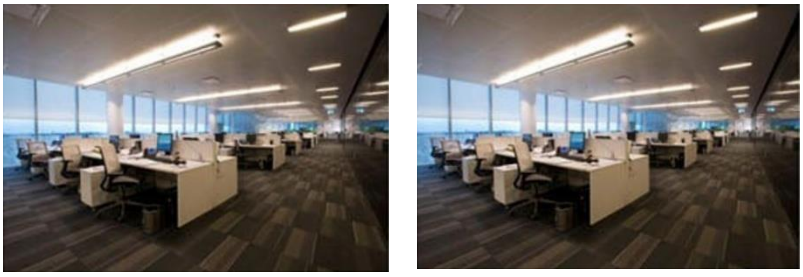
- **First case study: Dar Al-Handasah Smart Village Offices building (Building A)**

The first case study, located in Smart Village, Cairo, Egypt, pertains to the Dar Al-Handasah Smart Village Offices building, designed by Perkins + Will and constructed by Orascom Contraction with an area of 41,800 square meters; the project reached completion in 2014, obtaining LEED NC v 2009 Gold certification on September 3rd, 2015. Renowned for its innovative design and sustainability features, the six-story headquarters exemplify Dar Al-Handasah's commitment to energy efficiency and environmental stewardship.

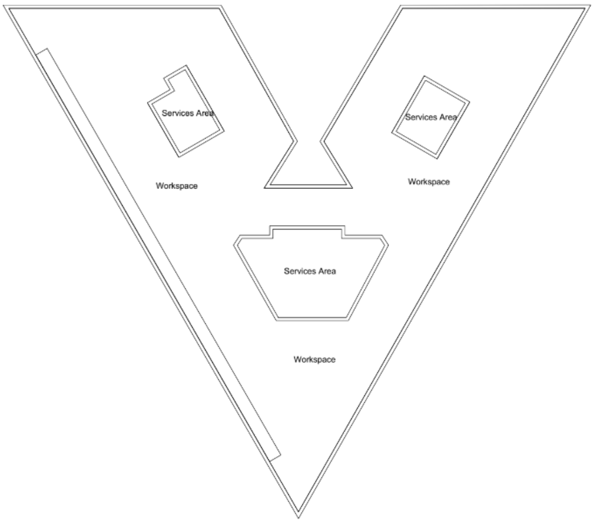
The building's architectural design incorporates a vertical shading system and an atrium, optimizing natural light penetration and indoor comfort. Notably, the executive area of the building adheres to the Zero Carbon Standard, showcasing Dar Al-Handasah's dedication to reducing carbon emissions. The project's energy consumption has been significantly reduced, achieving a 26% decrease through design innovations and sustainable practices. Achieving LEED Gold certification, the Dar Al-Handasah Smart Village Offices amassed 62 points on the New Construction Rating System, affirming its adherence to stringent sustainability standards. The building accommodates approximately 2,000 staff members, providing a conducive work environment that merges functionality with aesthetic appeal. The building's facade and interior design contribute to its energy efficiency and daylighting performance. Features such as double-pane low-E argon-filled windows, reflective interior walls and flooring, and high-reflectance ceilings enhance natural light utilization while minimizing heat gain and glare. Design strategies like light shelves, skylights, and atriums further optimize indoor daylight distribution and visual comfort. Comparative analysis reveals significant improvements in daylight autonomy and illuminance levels between the base and as-built cases, showcasing the effectiveness of design interventions in enhancing indoor environmental quality. Contact Interiors provided customized partition solutions, integrating specialized laminated glass with existing gypsum board walls to maximize daylight penetration and spatial flexibility.

The Dar Al-Handasah Smart Village Offices serve as the headquarters for an engineering company (Figure 2), featuring six floors and a predominantly open-plan workspace layout. Departmental managers' offices are characterized by glass walls, promoting transparency and collaboration. Vertical circulation is facilitated by eight elevators and an internal staircase, ensuring efficient movement within the building. Most workspaces offer views of the surrounding open spaces through the glass facade, fostering connectivity with the outdoor environment. Advanced automation systems control lighting and air conditioning, enhancing operational efficiency and occupant comfort. Table 1 outlines various sustainable practices employed within the building, highlighting its commitment to creating a sustainable work environment.

(a) Building Exterior Image



(b) Building Interior Images



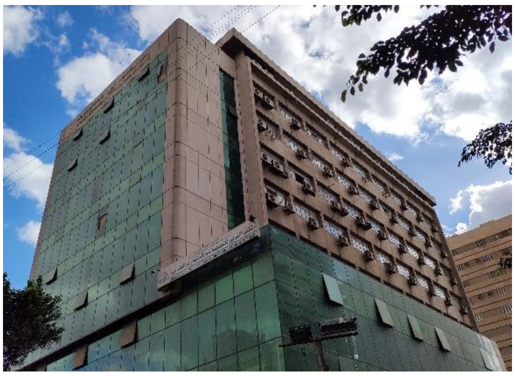
(c) Building Schematic Plan

Fig. 2. Dar Al-Handasah Smart Village Offices building (Building A)

- **Second case study: The Arab Office for Engineering Designs and Consultations (Building B)**

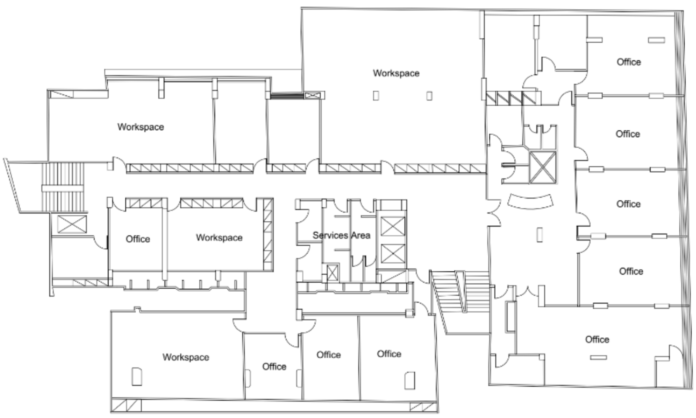
The Arab Office for Engineering Designs and Consultations (Figure 3) is strategically located in Abbasiya Square, extending from Ramses Street, opposite the Police College, at the corner of Fakhri Abdel Nour Street, marking the onset of Nasr City. This prominent office building is tall and has nine floors, with the office occupying five of these floors, as depicted in Figure 3. The office space is thoughtfully distributed across these floors to effectively accommodate various departments and functions.

Essential facilities such as the security office, library, archives, and space management facilities are housed on the ground floor. Moving to the first floor, one finds administrative affairs, the training center, the general director's follow-up office, warehouse management, printing presses, technical and electronic archives, and a clinic. The second floor is dedicated to key personnel, including the Chairman of the Board of Directors, the Managing Director, the Head of the Technical Office Sector, and the general departments associated with technical office operations and personnel affairs. On the third floor, one finds the head of the financial affairs and investment sectors, along with general departments overseeing financial affairs and investment operations. The fourth floor is designated for the supervision of implementation activities, encompassing the head of implementation supervision sectors, general departments related to supervision, the head of the complementary works design sector, and respective general departments alongside the general administration of measurements. Moving up to the fifth floor, it serves as the hub for technical affairs related to design and urban planning. This includes general departments for architectural design and urban planning, the head of the civil engineering design sector, the general administration for decoration and models, the general administration for designing educational and training projects, and meeting rooms. Additionally, a significant portion of this floor is dedicated to the artistic archive, occupying a large hall supplemented by a smaller room featuring two closets for storage. This thoughtful space allocation ensures efficient workflow and departmental functionality, facilitating seamless operations within the Arab Office for Engineering Designs and Consultations.



(a) Building Exterior Image

(b) Building Interior Images



(c) Building Schematic Plan

Fig. 3. The Arab Office for Engineering Designs and Consultations Building (Building B)

4. Results

- Walk-through evaluation

During the walkthrough evaluation of the Dar Al-Handasah building, several key observations were made that highlight the effectiveness and thoughtfulness of its design. These observations provide insight into how the building's features contribute to the overall comfort and efficiency of the workspace. We observed several distinctive features during our visit to the Dar Al-Handasah building. The building boasts excellent natural lighting quality, with minimal reliance on artificial lighting, creating a bright and energy-efficient environment. The interior design promotes ease of movement and freedom of office layout, allowing for flexible arrangement of departments and workspaces. Calming colors throughout the building enhances visual comfort, while the advanced technological systems streamline operations and improve efficiency.

Furthermore, the building has well-organized ventilation systems, ensuring high indoor air quality. The exterior views from the building are also notable, providing a visually soothing environment for the occupants. These design elements collectively contribute to a comfortable, efficient, and aesthetically pleasing workspace, demonstrating a high standard of architectural design and thoughtful consideration of the users' needs. During our visit to the Arab Office for Engineering Designs and Consultations, we observed several noteworthy aspects of the building's design and management. The office effectively manages and utilizes its space to maximize comfort and efficiency, demonstrating ongoing building mechanisms and strategy improvements. The building's façade, using concrete surfaces and transparent glass panels, reflects a contemporary identity and modern aesthetic. The interior design supports easy communication among colleagues while maintaining sufficient individual workspaces. Additionally, the design allows users to control the lighting in their spaces, showcasing a flexible approach that caters to user needs and preferences. We also noted that the office layout promotes visual relief and accessibility, ensuring that workspaces are well-illuminated and ventilated. Thermal comfort is adequately maintained with natural and artificial ventilation systems. Indoor air quality is enhanced by the building's strategic design, which includes sufficient window areas for proper ventilation. Combining modern architectural design, efficient space utilization, and flexible lighting and ventilation provides a comfortable and productive working environment.

- Interview with occupants

The following section presents insights from employee interviews in the two case studies. These interviews aimed to evaluate various aspects of the office space, including visual relief, thermal comfort, indoor air quality, lighting quality, and architectural design. Through firsthand accounts and perspectives, this section provides valuable insights into the experiences and perceptions of employees regarding their workspace environment. For the first case study, the interview revealed the following results from the Dar Al-Handasah Smart Village Offices building.

- Visual Relief: Occupants generally expressed satisfaction with the interior design of Dar Elhanadssa's building, highlighting its suitability and adequacy for their tasks. The open layout facilitated easy communication among colleagues while allowing for visual connectivity and a conducive work environment.
- Thermal Comfort: Feedback regarding thermal comfort indicated mixed sentiments. While some appreciated the design's alignment with internal thermal conditions, others expressed concerns about their inability to control the temperature directly, negatively affecting their physical well-being and productivity.
- Indoor Air Quality: Responses regarding indoor air quality were varied. While some occupants acknowledged the presence of natural and artificial ventilation systems, others highlighted challenges in controlling air circulation, occasionally impacting their comfort and concentration levels.
- Lighting Quality: The assessment of lighting quality revealed differing opinions among occupants. While some appreciated the sufficient lighting for task completion, others expressed concerns about the uniformity and adequacy of illumination in certain areas, citing it as a factor affecting visual comfort and productivity.
- Architectural Design: Overall, occupants lauded the architectural design of Dar Elhanadssa's building, noting its compatibility with their functional needs and aesthetic preferences. Features such as ceiling height and color schemes were generally well-received, contributing to a visually appealing and conducive work environment.

For the second case study, the Arab Office for Engineering Designs and Consultations, the interview reveals the following results.

- Visual Relief: Overall, respondents expressed satisfaction with the interior design of the Arab Office for Engineering building, highlighting its suitability and adequacy for their tasks. The open layout facilitated communication among colleagues and allowed for visual connectivity, contributing to a conducive work environment.
- Thermal Comfort: Feedback regarding thermal comfort varied. While some occupants appreciated the building's design in maintaining suitable thermal conditions, others expressed concerns about their inability to control the temperature directly, negatively impacting their physical well-being and productivity.
- Indoor Air Quality: Responses regarding indoor air quality were mixed. While some acknowledged the presence of ventilation systems, others highlighted challenges in controlling air circulation, impacting their comfort and concentration levels at times.
- Lighting Quality: The assessment of lighting quality revealed differing opinions. While some appreciated sufficient lighting for task completion, others expressed concerns about the uniformity and adequacy of illumination in certain areas, affecting visual comfort and productivity.
- Architectural Design: Occupants generally praised the architectural design of the Arab Office for Engineering building, noting its alignment with their functional needs and aesthetic preferences. Features such as ceiling height and color schemes were well received, contributing to a visually appealing and conducive work environment.

- **Questionnaire results**

Formulating the questionnaire involved carefully considering various factors impacting occupant comfort and building performance. The questions were designed to gather comprehensive feedback on environmental conditions, user satisfaction, and overall experience within the office building. Each question was tailored to address specific aspects relevant to the research objectives. The questionnaire was thoughtfully crafted to encompass various dimensions of occupant experience and building performance, organized into distinct categories: Firstly, the questionnaire addressed Natural Light and Visual Comfort, probing occupants' comfort levels with natural light and the effectiveness of curtains in light control. Secondly, it delved into Artificial Lighting, evaluating the sufficiency of lighting for work tasks within the space. Thermal comfort was assessed through questions regarding occupants' sensations of warmth in the morning sunlight and perception of cold during winter, falling under the category of Thermal Comfort. Ventilation and Air Quality were scrutinized to gauge occupants' satisfaction with ventilation systems and humidity levels, which are crucial for maintaining a comfortable indoor environment. Acoustic comfort was evaluated through inquiries about noise disturbance from adjacent offices and the street, ensuring a conducive work environment. The questionnaire also addressed Internal Environment Quality, encompassing air movement adequacy and the sufficiency of window areas for ventilation. Accessibility and Proximity were explored to determine the appropriateness of distances within the building, from the entrance to the office, and between colleagues' workstations. Spatial Comfort and Functionality were assessed through questions regarding overall office comfort and the suitability of floor finishes for movement. Circulation and infrastructure were considered, and the adequacy of internal roads for movement within the building was evaluated. The questionnaire also included inquiries about building modifications to capture any building structure or system alterations. Aesthetics and Exterior Views were examined to determine occupants' satisfaction with the building facade and street views. Workspace Design and Comfort were evaluated through questions regarding desk spacing, ensuring ergonomic and functional workspaces. Finally, Occupant Experience was probed to assess occupants' sense of belonging to the workplace, contributing to overall satisfaction and well-being. This systematic categorization ensured a comprehensive evaluation of occupant perceptions and the building's physical attributes, providing valuable insights into its performance. The following are the results revealed from the questionnaire for different categories.

- **Results of analyzing questions related to the visual relief part**

A user survey explored satisfaction with lighting and visual Comfort in Buildings A and B. The average perceived brightness was slightly higher in Building B (62.54%) compared to Building A (58%). Interestingly, user responses indicated a higher percentage of finding the lighting level "extremely bright" in Building A (59.56%) compared to Building B (55.6%). Artificial lighting satisfaction followed a similar trend. Over 62.5% of Building A user's reported satisfaction, while only 55.23% of Building B users expressed the same sentiment. Natural light usage also differed between the buildings. While 46.25% of Building A users expressed extreme satisfaction with natural lighting, only 24% of Building B users shared this sentiment. This difference might be attributed to the effectiveness of window treatments, with 7.85% of Building B occupants reporting that curtains effectively block natural light (data for Building A's window treatments not provided). Overall, visual comfort appeared slightly higher in Building B, with over 90.56% of users rating it as "medium."

In contrast, 8.25% of Building A users reported dissatisfaction with visual comfort. Privacy concerns were also slightly higher in Building A, with 8.25% of users expressing dissatisfaction compared to 5.25% in Building B (Figure 4). These findings suggest investigating user preferences for lighting levels and natural light control in both buildings. Optimizing window treatments and exploring user feedback on brightness and visual comfort could improve occupant satisfaction in Buildings A and B.

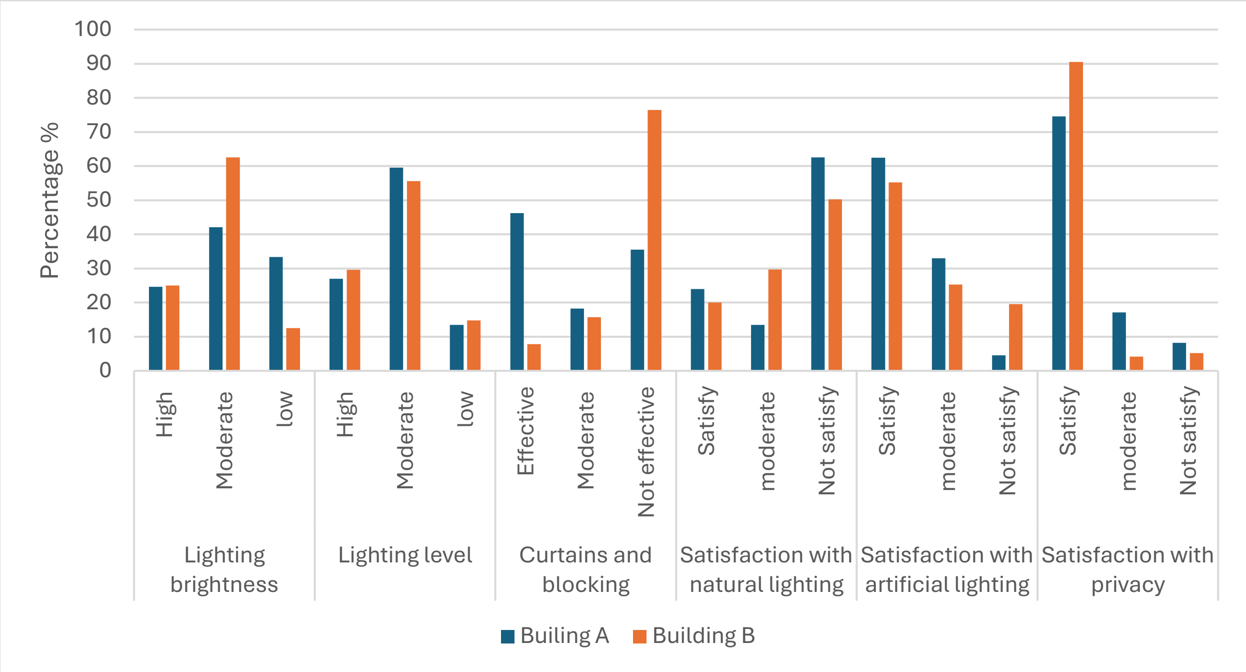


Fig. 4. Results of analyzing questions related to the visual relief part

- **Results of the analysis of questions related to thermal comfort**

The survey results reveal distinct user preferences regarding summer and winter temperatures within Buildings A and B. In summer, Building A users tend to experience cooler temperatures, with 7.65% reporting a cool environment. Conversely, most Building B users (75.2%) report a medium temperature in summer. This trend continues in winter, with Building A users experiencing a more comfortable environment. In contrast, 30.36% of Building A users find the winter temperature average, and a significantly higher proportion (65.3%) report satisfaction. In Building B, a more significant portion (25.4%) considers the winter temperature average, indicating a less pronounced user satisfaction than in Building A.

Building B users report higher satisfaction with summer humidity, with 83% expressing moderate satisfaction Figure 5. However, Building A users seem less satisfied with summer humidity, with a significant portion (78%) expressing dissatisfaction Figure 5. This result aligns with the general observation that user satisfaction appears higher in winter than in summer, likely due to the inherent challenges of cooling buildings effectively compared to heating. The result suggests that Building A users experience a more comfortable thermal environment in summer and winter. This can be attributed to cooler summer temperatures and a higher percentage of users satisfied with the winter temperature. Building B users, while experiencing medium temperatures in summer, seem less satisfied with both summer and winter compared to Building A. Humidity also plays a role, with Building B users expressing greater satisfaction with summer humidity levels.

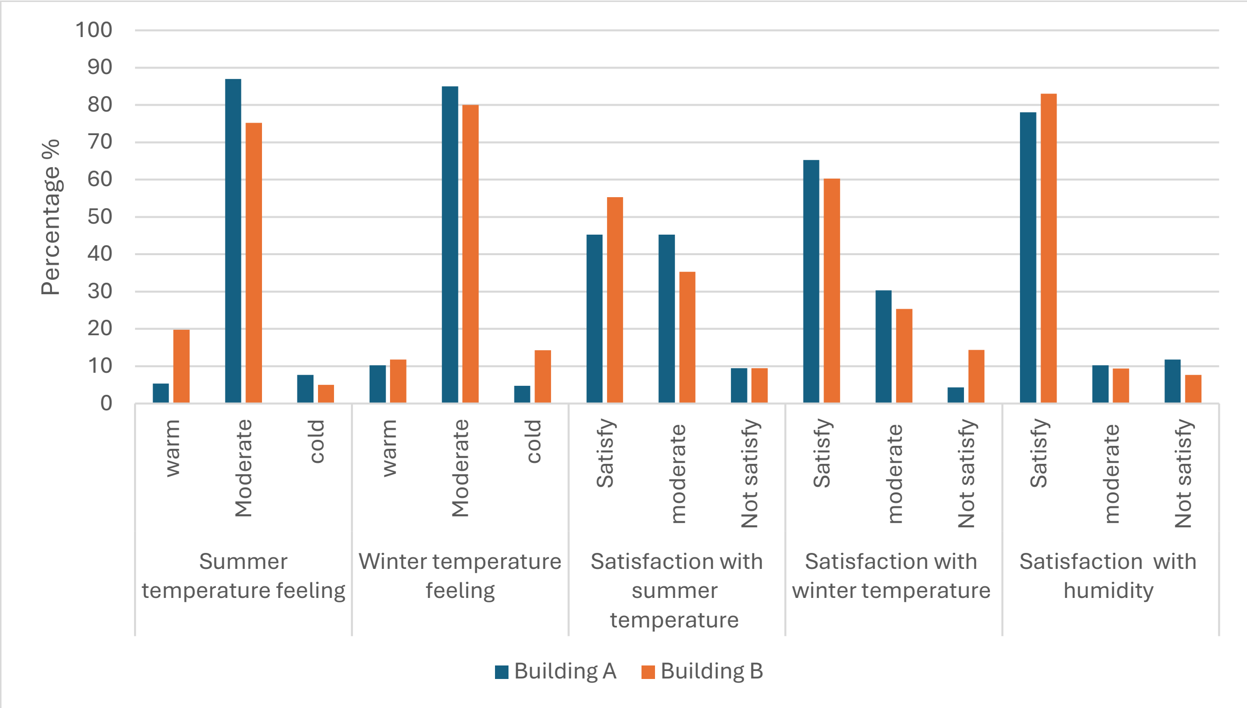


Fig. 5. Results of the analysis of questions related to thermal comfort

- **Results of the analysis of indoor air quality**

The survey results reveal a significant difference in user perception of indoor air quality between Buildings A and B. Over 75% of Building B users reported average indoor air quality, while a concerning 9.35% of Building A users reported poor air quality. This discrepancy extends to perceived air cleanliness, with over 88% of Building B users finding the air clean and average, compared to 85% in Building A, which reported good air quality. User satisfaction with various aspects of air quality also differed. Building B users expressed higher satisfaction with air humidity (78% satisfied) than Building A users (43% satisfied). Similarly, 78% of Building B users were satisfied with the building's ventilation system (artificial), whereas only 53% of Building A users shared the same sentiment. However, natural air movement appears more favourable in Building A, with 60.26% of users dissatisfied with it (potentially indicating a desire for more natural ventilation).

In contrast, only 30.36% of Building B users expressed moderate satisfaction with natural airflow. These contrasting preferences highlight the importance of considering user feedback when designing and managing natural ventilation systems. Overall, the data suggest that Building B provides a superior indoor air environment compared to Building A. The significantly higher percentage of users in Building A reporting poor air quality, lower satisfaction with air humidity, and dissatisfaction with artificial ventilation are points of concern. Further investigation and potential improvements to Building A's air quality management system are warranted to create a healthier and more comfortable environment for its occupants (Figure 6).

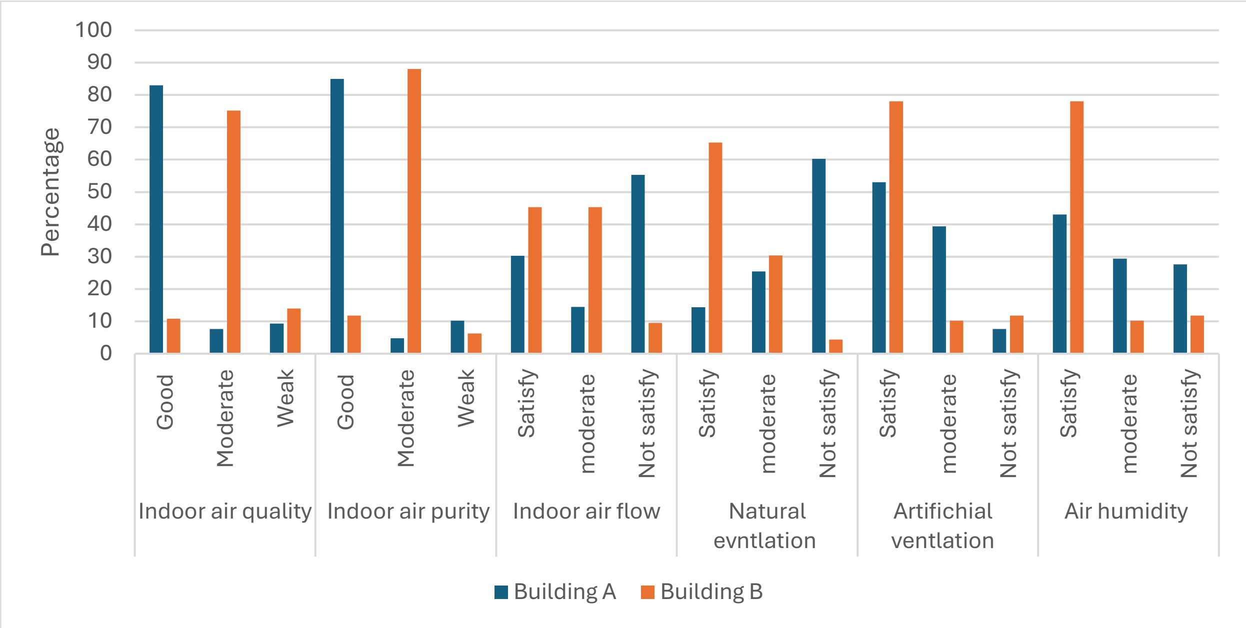


Fig. 6. Results of analyzing questions related to indoor air quality.

- **Results of analysis questions related to the visual relief component**

The survey explored user perceptions of how lighting quality impacts work performance in Buildings A and B. Interestingly, user responses regarding the effect of lighting quality on work performance differed. While 42.4% of Building B users considered the impact to be average, 38.5% of Building A users reported no effect at all. Air quality seems to be a more significant concern in Building B, with 48.5% of users reporting a moderate negative impact on work performance. Building A users' responses were less clear, with 30.8% finding the effect negligible and an equal percentage finding it highly impactful. Noise distraction appears to be a similar concern in both buildings, with 36.4% of Building B users and 30.8% of Building A users reporting a moderate negative impact on work performance. However, user perspectives on the overall influence of the building environment on productivity diverged. A significantly higher percentage of Building A users (69.2%) believe the internal environment substantially impacts work performance than Building B users (39.4%). This result aligns with their perception of office design; 38.5% of Building A users find the design to assist their work significantly, while only 45.4% of Building B users consider the impact moderate (Figure 7). These findings suggest a potential need to address environmental factors that may hinder productivity in Building A. Investigating user feedback on lighting quality, air quality, and noise concerns could lead to improvements that enhance occupant well-being and performance. In contrast, Building B users perceive the environment as having a more moderate impact on productivity, suggesting a potentially more optimized workspace layout and design.

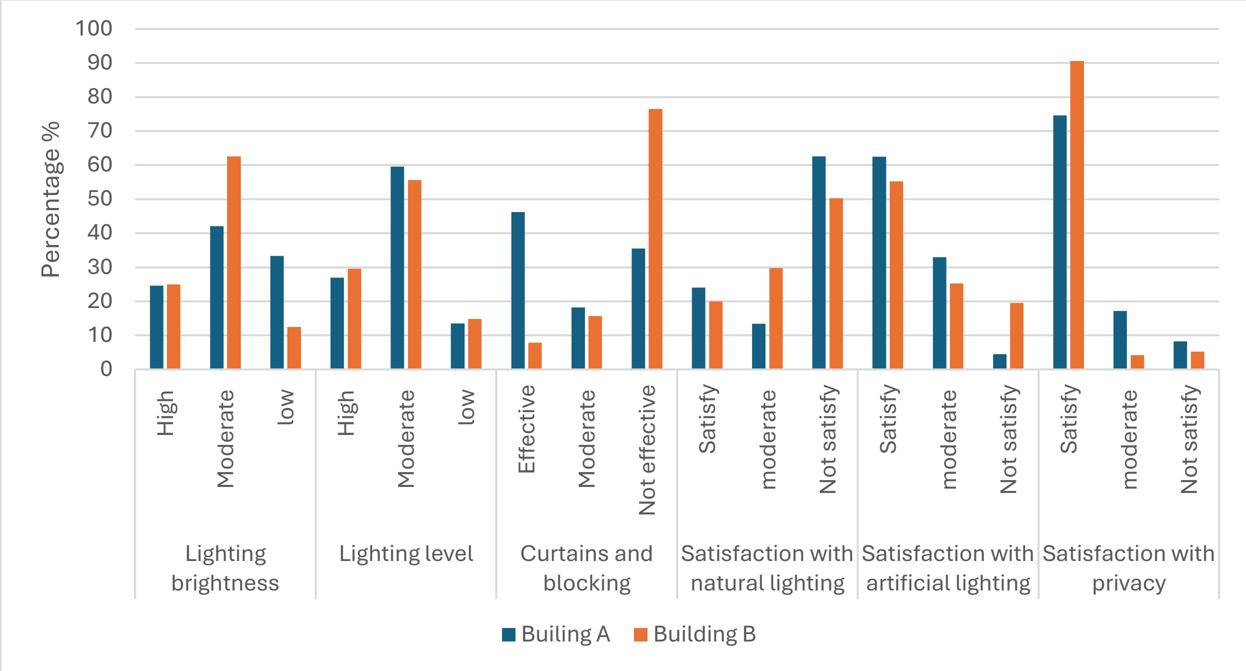


Fig. 7. Results of analyzing questions related to the lighting quality

- **Results of the analysis of architectural design**

The survey delves into user satisfaction with various architectural design elements in Buildings A and B. Building A users expressed significantly higher satisfaction with interior finishes. A noteworthy 69.2% reported being highly satisfied, compared to a more moderate 45.4% of Building B users. Office layout preferences appear to differ between the buildings. While 30.8% of Building A users are satisfied with the layout, a higher percentage of Building B users (36.4%) expressed moderate satisfaction with the overall office design. This result suggests that users in Building B may have a more neutral perception of the layout while desiring specific design improvements. Building A users also reported higher satisfaction with their immediate workspace area than Building B. Over 30% of Building A user's expressed satisfaction, while 55.26% of Building B users were moderately satisfied. This trend continues with workspace furniture, where 65.28% of Building A users reported high satisfaction compared to 45.5% in Building B. Accessibility also appears to be a point of differentiation. While nearly half (48.5%) of Building B users found their workspace easily accessible from the building entrance, only 53.8% of Building A users expressed moderate satisfaction with accessibility. These findings highlight the importance of considering user feedback when designing and maintaining office spaces. Building A users seem particularly satisfied with interior finishes, furniture, and their immediate workspace environment. However, lower satisfaction with office layout and accessibility suggests areas for potential improvement. In contrast, Building B users tend to have a more moderate level of satisfaction across most design elements, potentially indicating a need for user-specific design adjustments to enhance their experience further (Figure 8).

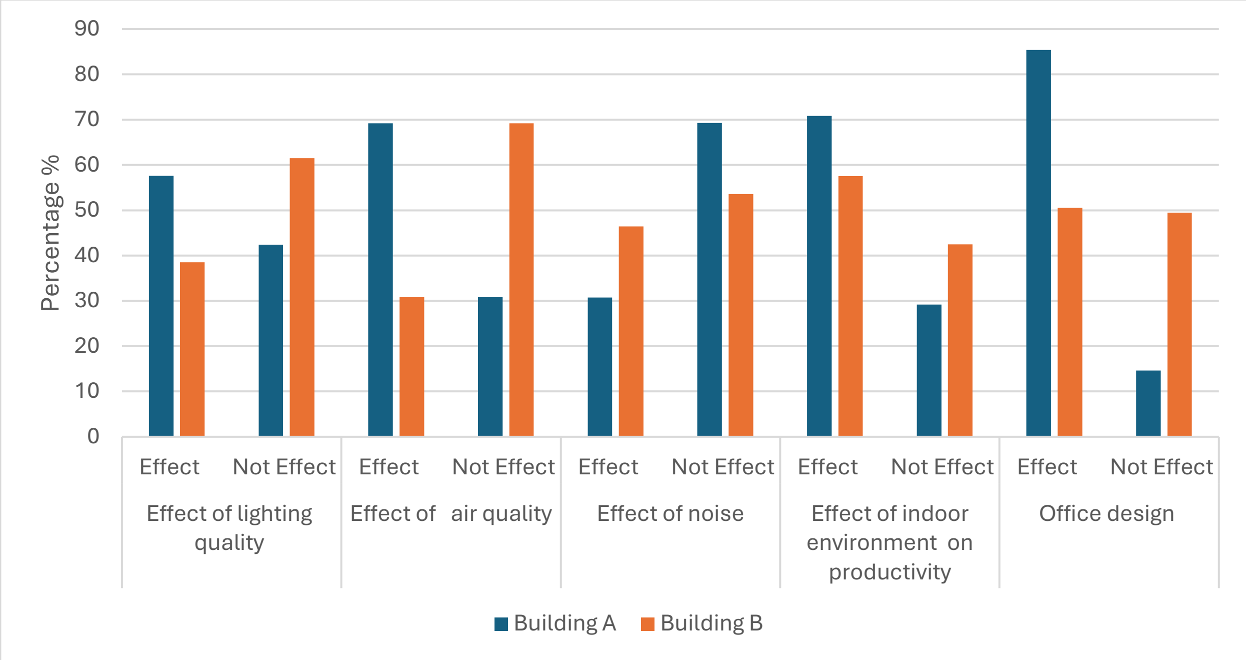


Fig. 8. The results of analyzing questions related to the architectural design element

5. Discussions

The post-occupancy evaluation (POE) of two engineering office buildings—one with automation (Building A: Dar Al-Handasah Smart Village Offices) and one without (Building B: The Arab Office for Engineering Designs and Consultations)—reveals critical insights into how indoor environmental quality (IEQ) and architectural design influence occupant satisfaction and productivity. To enhance coherence, this discussion organizes findings under thematic headings based on the key aspects evaluated: Visual Relief, Thermal Comfort, Indoor Air Quality, Lighting Quality, and Architectural Design. Each theme integrates quantitative survey data, qualitative interview and walkthrough insights, and comparisons with existing literature, culminating in a synthesis of broader implications. A final subsection ties these themes together, offering an overall assessment and recommendations tailored to the Egyptian context.

- **Visual Relief**

Visual relief, encompassing natural light usage, visual comfort, and privacy, emerged as a significant factor in occupant satisfaction. In Building A, 46.25% of occupants expressed extreme satisfaction with natural light, attributed to large windows, light shelves, and an atrium design, aligning with Edwards and Torcellini (2002) on daylight's positive impact on well-being. Walkthroughs confirmed excellent natural lighting with minimal artificial reliance, enhancing energy efficiency and visual comfort. Conversely, Building B showed only 24% extreme satisfaction, with 7.85% noting effective curtain use but insufficient window areas limiting light penetration. Interviews in both buildings praised open layouts for facilitating communication, though Building A reported slightly higher privacy concerns (8.25% dissatisfied vs. 5.25% in Building B). These findings suggest that while natural light boosts satisfaction, optimizing window treatments and balancing openness with privacy are key to enhancing visual relief, particularly in Egypt's sunny climate.

- **Thermal Comfort**

Thermal comfort varied significantly between the buildings, influenced by automation and control systems. Building A users reported cooler summers (7.65% noted a cool environment) and higher winter satisfaction (65.3%), linked to advanced HVAC systems allowing personalized control, supporting Frontczak and Wargocki (2011) on the importance of temperature regulation. Interviews highlighted mixed sentiments, with some occupants desiring more direct control. In Building B, 75.2% experienced medium summer temperatures, but only 25.4% found winter temperatures satisfactory, reflecting challenges in maintaining comfort without automation. Walkthroughs noted adequate natural ventilation in Building B, yet thermal regulation remained inconsistent. This comparison underscores automation's role in achieving thermal comfort in Egypt's extreme climate, though occupant control remains a critical factor for satisfaction.

- **Indoor Air Quality**

Indoor air quality (IAQ) showed notable differences, with Building B outperforming Building A. Over 75% of Building B users rated IAQ as average, with 88% finding air clean and 78% satisfied with ventilation and humidity, aided by strategic window placement observed during walkthroughs. In contrast, 9.35% of Building A users reported poor IAQ, with only 53% satisfied with artificial ventilation despite good air cleanliness (85%). Interviews revealed varied perceptions, with Building A occupants desiring more natural air movement (60.26% dissatisfied). These findings align with Seppänen et al. (1999), linking poor ventilation to reduced productivity, suggesting that Building A's automation, while effective for temperature, may compromise IAQ unless paired with enhanced natural ventilation—a critical consideration in Egypt's urban settings.

- **Lighting Quality**

Lighting quality, blending natural and artificial sources, influenced work performance differently across the buildings. Building A's strategic use of both lighting types yielded positive interview feedback and a 62.5% artificial lighting satisfaction rate, reflecting Veitch (2001) on balanced lighting reducing eye strain. However, 38.5% of users reported no impact on performance, indicating room for optimization. Building B showed 55.23% artificial lighting satisfaction, with 42.4% rating its performance impact as average, and walkthroughs confirmed flexible lighting control. Survey data highlighted higher visual comfort in Building B (90.56% medium rating vs. 8.25% dissatisfaction in Building A), yet both buildings faced uniformity concerns in interviews. This suggests that while Building A leverages automation for lighting, both could benefit from tailored solutions to enhance productivity, especially in task-diverse engineering offices.

- **Architectural Design**

Architectural design, including layout and aesthetics, was well received, with distinct strengths in each building. Building A users reported 69.2% high satisfaction with interior finishes and 65.28% with furniture, bolstered by an open-plan design praised in interviews for collaboration (Heerwagen et al., 2004). Walkthroughs noted calming colors and technological integration, enhancing functionality. Building B showed 45.4% moderate satisfaction with finishes and 48.5% with accessibility, with interviews lauding its modern façade and communication-friendly layout. However, noise in Building A's open spaces and moderate layout satisfaction in Building B (36.4%) indicate trade-offs. These findings highlight the design's role in fostering work culture, with Egypt's context emphasizing adaptability and aesthetics in office settings.

- **Overall Synthesis and Recommendations**

Synthesizing these themes, natural light, thermal control via automation, and thoughtful design significantly enhance occupant satisfaction and productivity, though challenges like IAQ, lighting uniformity, and noise persist. Building A's automation excels in thermal and lighting quality but falters in IAQ, while Building B leverages natural ventilation and accessibility but struggles with thermal consistency. In Egypt's hot climate and urbanizing landscape, these findings fill a POE research gap, advocating for designs prioritizing natural elements and user control. Recommendations include:

- Enhancing Natural Light: Increase window areas and light shelves to boost visual relief and energy efficiency.
- Improving Thermal Comfort: Equip buildings with advanced HVAC and individual controls, especially in non-automated settings.
- Optimizing IAQ: Integrate modern ventilation with natural airflow to address health and productivity needs.
- Balancing Lighting: Combine natural and artificial lighting with user feedback to reduce strain and enhance performance.
- Addressing Acoustics: Use noise-reducing materials in open layouts to mitigate privacy and focus issues.

In the context of this research, the significance of Post-Occupancy Evaluation (POE) cannot be overstated. POE serves as a crucial tool for assessing the performance of architectural designs in real-world settings, offering valuable insights into how buildings function and how occupants interact with them. The discussion of POE's importance and impact on architectural design and building practices is pivotal in understanding the broader implications of this research.

Firstly, POE provides architects and designers with empirical data on the performance of their designs, allowing them to assess whether design intentions align with actual user experiences. By evaluating factors such as spatial layout, lighting, ventilation, thermal comfort, and acoustics, POE enables architects to identify strengths and weaknesses in their designs and make informed decisions for future projects. This iterative process of evaluation and refinement contributes to the evolution of architectural practice, ensuring that designs are responsive to user needs and preferences.

Furthermore, POE facilitates a deeper understanding of how architectural features affect occupant behaviour, satisfaction, and well-being. By analyzing user feedback and behaviour patterns, architects can identify design elements contributing to occupant comfort, productivity, and overall satisfaction. This insight allows architects to prioritize features that enhance the quality of life for building occupants, promoting user-centric design approaches.

Moreover, POE is vital in evaluating building performance regarding energy efficiency, environmental sustainability, and operational effectiveness. By monitoring key performance indicators such as energy consumption, indoor air quality, and environmental impact, architects and building owners can identify opportunities for optimization and resource conservation. This data-driven approach to building performance evaluation supports sustainability goals and informs decision-making processes for building operation and maintenance.

The findings underscore the need to integrate cultural and climatic factors into office design, a consideration often overlooked in global POE studies. In hot, urbanizing regions like Egypt, balancing automation with natural ventilation and user control is critical for optimizing occupant satisfaction. Moreover, the identification of automation's limitations, such as reduced IAQ, provides a cautionary note for designers worldwide. By offering a comparative framework and context-specific insights, this study serves as a model for future POE research in developing countries, where rapid urbanization and technological adoption present unique design challenges.

This research directly contributes to several United Nations Sustainable Development Goals (SDGs), underscoring its broader relevance to global sustainability efforts. By enhancing indoor environmental quality (IEQ), the study supports SDG 3: Good Health and Well-being, specifically target 3.9, which aims to reduce illnesses from hazardous environments. The recommendations for energy-efficient systems, such as optimized lighting and ventilation, align with SDG 7: Affordable and Clean Energy, particularly target 7.3, which focuses on improving energy efficiency. The emphasis on creating better workplace conditions ties into SDG 8: Decent Work and Economic Growth, supporting target 8.8 on promoting safe and secure working environments. Additionally, the findings on sustainable building practices contribute to SDG 11: Sustainable Cities and Communities, specifically target 11.6, which addresses reducing the environmental impact of cities. Finally, by promoting climate-responsive design, this research aids SDG 13: Climate Action, particularly target 13.2, which calls for integrating climate change measures into policies and planning. These explicit linkages highlight the study's role in advancing global sustainability goals.

6. Conclusions

This research has provided valuable insights into the performance of the selected office buildings through Post-Occupancy Evaluation (POE). The findings reveal several key points.

Firstly, the evaluation highlighted the importance of visual relief, thermal comfort, indoor air quality, and lighting quality influencing occupant satisfaction and productivity. Secondly, the study identified areas for improvement in both buildings, including the need for better noise control, ergonomic furniture, and more flexible lighting solutions. However, it's essential to acknowledge the limitations of this research. The sample size was relatively small, and the study focused on a specific type of building, which may limit the generalizability of the findings.

Additionally, the research relied on subjective assessments from occupants, which may introduce bias into the results. Future research could expand the scope of the study to include a broader range of building types and locations. Longitudinal studies could provide valuable insights into how occupant satisfaction and building performance evolve. Additionally, incorporating objective measurements, such as environmental sensors, could help provide a more comprehensive understanding of building performance. Overall, this research underscores the importance of ongoing evaluation and refinement of architectural designs to create healthier, more comfortable, and productive built environments.

This research advances the global POE field by introducing a comparative analysis of automated and non-automated engineering offices in Egypt, revealing new findings about automation's trade-offs, and highlighting the importance of context in office design. These contributions provide actionable insights for practitioners and a foundation for further studies in similar climates and cultures. Also, this study contributes to SDG 3 by reducing health risks, SDG 7 by enhancing energy efficiency, SDG 8 by improving work environments, SDG 11 by promoting sustainable cities, and SDG 13 by supporting climate action. These connections solidify the research's relevance and its role in advancing global sustainability.

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