

Weighting the Indoor Environmental Quality on Work Performance

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ABSTRACT

Poor indoor environmental conditions are often associated with reduced concentration, lower motivation, and decreased productivity in office settings. Addressing this issue requires a systematic assessment of Indoor Environmental Quality (IEQ) and its contribution to work performance. This study examines the effect of Indoor Environmental Quality (IEQ) on office worker performance, focusing on five components: Indoor Air Quality (IAQ), Thermal Comfort, Lighting Quality, Acoustic Quality, and Occupant Experience. The Best-Worst Method (BWM) was applied to determine the relative importance of these factors through a combination of subjective surveys and objective weighting using linear programming. Results indicate that Occupant Experience, particularly ergonomic improvements such as adjustable furniture and optimized layouts, has the strongest influence on productivity. Thermal Comfort ranks second, followed by Lighting Quality, Acoustic Quality, and IAQ. Sensitivity analysis confirms the robustness and consistency of the findings. This research contributes by offering a systematic weighting of IEQ factors, highlighting the central role of ergonomics in workplace design. The study emphasizes that integrating ergonomic and environmental considerations is essential to improve worker performance. The novelty of this study lies in integrating Occupant Experience into the BWM framework, providing a more comprehensive model of IEQ and offering new insights for designing healthier and more productive office environments.

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1. Introduction

Diverse environmental conditions are inseparable from human existence, and there is a very close bond between humans and their environment. In this context, humans will always strive to adapt to varying environmental conditions ([Aswar et al., 2022](#)). The conditions of the indoor environment can influence both physiological and psychological responses, which in turn may affect an individual's psychomotor, perceptual, and cognitive functions essential to achieving job satisfaction ([Porras-Salazar et al., 2021](#)). Additional complicating factors may have an effect on work performance as it is a secondary indication of the influence of the internal environment ([Elnaklah et al., 2020](#)). An indoor setting that provides comfort can effectively minimize occupant complaints and lead to improved work productivity ([Felgueiras et al., 2023](#)). Employee productivity and work quality are significantly

influenced by their work environment (Udanarti & Kasmir, 2022). An organization's work environment consists of physical and non-physical aspects that are unrelated to humans (Duque et al., 2020). Human comfort is significantly influenced by the thermal environment (Lan et al., 2021; Luo et al., 2022; C. Song et al., 2021).

The nervous system acts in a related manner, therefore environmental lighting can impact how well tasks involving emotions, cognition, and executive functions are performed (Sun et al., 2021). Interior environmental standards are directly related to human comfort indoors, often evaluated in four dimensions: thermal, visual, auditory, and respiratory (Y. Song et al., 2021). Low levels of Indoor Environmental Quality (IEQ) are often linked to reduced concentration, diminished workplace motivation, and overall poor job performance among office employees (Liu et al., 2022). Currently, there is a substantial amount of data showing the relationship between workplace standards and personnel productivity (Sadick et al., 2020). Most studies examining the relationship between workplace IEQ and productivity have emphasized IEQ (Lou & Ou, 2019). As organizations increasingly recognize the role of the physical environment in shaping employee well-being and productivity, the demand for a structured evaluation of IEQ has become more urgent.

Previous studies have established that thermal comfort, air quality, lighting, and acoustics are the dominant dimensions of IEQ affecting workplace outcomes. First, prior studies collected subjective data based on questionnaire surveys (Atef et al., 2018). For data collected through surveys, responses to the same questions can vary depending on the question structure, and errors can occur in the process of interpreting respondents' thoughts. Therefore, objective data collection is needed to more scientifically measure the individual weights of IEQ components. Second, previous research Danza et al., (2020) only considered the combined effects of four IEQ components, namely thermal comfort, visual comfort, acoustic comfort, and air quality.

This study uses a combination of five IEQ components: Indoor Air Quality (IAQ), Thermal Comfort, Lighting Quality, Acoustic Quality, and Occupant Experience. The application of Occupant Experience in this study involves ergonomic improvements. Ergonomic improvements include adjustable furniture, ergonomic chairs, and optimized workspace layouts, which have been proven to reduce musculoskeletal disorders and enhance business process efficiency. Factors such as adequate lighting, comfortable temperature, minimal noise, and appropriate computer monitors contribute to employee comfort and performance improvement (Faez et al., 2021; Heidarimoghadam et al., 2022; Kumar & Bezawada, 2019). A notable gap in the literature is the limited attention to the role of occupant or occupant experience, especially ergonomic aspects such as adjustable furniture, optimized workspace layouts, and supportive equipment. These factors directly influence musculoskeletal health and task efficiency but are rarely included in systematic weighting models of IEQ. This study addresses this gap by introducing *Occupant Experience* as an additional dimension to the Best-Worst Method (BWM), offering a more comprehensive assessment framework. The novelty of this work is the incorporation of Occupant Experience into the IEQ evaluation model, highlighting its significant impact compared to traditional factors.

Earlier research on Indoor Environmental Quality (IEQ) has revealed several notable limitations. Most studies primarily relied on subjective questionnaires, which are prone to interpretation bias and variability in responses, thereby reducing the reliability of findings. As a result, previous approaches often lacked precision and provided only a partial understanding of how the indoor environment shapes employee performance and well-being. The urgency of this research, therefore, lies in establishing a more comprehensive and scientifically rigorous framework that integrates both environmental and ergonomic dimensions. Such an approach enables a clearer assessment of their relative influence on worker performance and addresses the shortcomings of earlier studies. To achieve this objective, the Best-Worst Method (BWM) was selected for its methodological advantages, including reduced inconsistency and efficiency in pairwise comparisons, while sensitivity analysis was applied to validate the robustness of the results. This study also builds upon theoretical perspectives from ergonomics and work psychology, which highlight the critical interplay between environmental factors, human comfort, and cognitive functioning. Together, these foundations

provide a strong rationale for advancing IEQ research toward more holistic and evidence-based workplace standards.

This study contributes both theoretically and practically. Theoretically, it refines the conceptual framework of IEQ by introducing Occupant Experience as a new component within the BWM model, an aspect rarely addressed in previous research. Practically, it provides actionable insights for workplace designers and policymakers to prioritize ergonomic improvements alongside traditional environmental factors. The main objective of this study is to establish a systematic weighting of IEQ components that highlights the significant role of occupant experience in enhancing productivity and well-being. By emphasizing this unique dimension, the research not only advances academic discussions on IEQ but also offers practical guidance for creating healthier and more productive office environments.

2. Method

2.1. Indoor Air Quality Theory

Indoor Air Quality (IAQ) is defined by the effectiveness of a building's ventilation system and the extent of pollutant emissions originating from furnishings, construction materials, and human activities within the space (Kang et al., 2017). The amount of ventilation and air freshness, levels of CO₂, CO, SO₂, VOCs, and particulates, as well as concentrations of carbon dioxide and other gases, are some of the commonly used physical indicators of Indoor Air Quality (IAQ) (Elnaklah et al., 2020). Two main ways to improve IAQ and enhance workplace productivity are by increasing ventilation rates and reducing pollutant concentrations (Gupta et al., 2019). Another crucial element that impacts the comfort and productivity of occupants is lighting. Two significant sources of lighting are natural and artificial lighting (Kang et al., 2017). Inadequate lighting may result in visual fatigue, difficulty maintaining attention, reduced energy levels, stress, lowered motivation, and decreased workplace efficiency (Thach et al., 2020). Additionally, occupants may feel a greater sense of openness and satisfaction with the quality of lighting (Sadick et al., 2020).

Depending on the type of office work being performed, different lighting conditions may be optimal. For example, Sun, Lian, and Lan shown how varying intensities and hues of light are ideal for participants' perception, learning, and memory function in contrast to their cognitive and executive processes (Sun et al., 2021). Noise is defined as unwanted sound (Thach et al., 2020). It can cause mental health problems, such as headaches and exhaustion (Di Blasio et al., 2019), interfere with attention and activities, increase distractions, lower productivity at work, and more. The primary sources of internal noise in office environments include mobility noise, including keyboard usage, door closures, humans activity, and foot traffic, as well as speech noise, which comprises speeches, calls through phone, and giggling (Kang et al., 2017). However, there can be wide variations in the ways that certain IEQ variables impact various cognitive processes; conversely, distinct IEQ factors can have very diverse effects on different cognitive functions (Delgado-saborit et al., 2021; Zhang et al., 2019). As a result, office employees do worse as well.

2.2. Data Collection

The experiment was conducted in a Climate Room. The Climate Room is an isolated space where practitioners conducted their practical work for this research, analysing the consequences of surrounding factors on worker performance. A field laboratory resembling an office was developed. The experiments were conducted in the field laboratory, which featured an indoor office space with dimensions of L, W, and H being 5 m, 7 m, and 5 m, respectively Fig. 1. Each workstation had a desk, chair, and multimedia keyboard connected to a computer via USB 2.0. The workplace requirements were determined based on the height of the volunteers. Ten volunteers sat at ergonomic VDT workstations as seen in Fig. 2. All participants (15 male and 15 females aged between 21-30 years old) were university students or early-career employees with basic computer skills, ensuring homogeneity in task familiarity. This study utilized several environmental elements deemed more

relevant to laboratory settings, including music-related noise, ambient temperature, air quality, lighting intensity, and a work environment that applies ergonomic principles.



Fig. 1. An isolated experimental office designed to control temperature, air quality, lighting, and acoustics

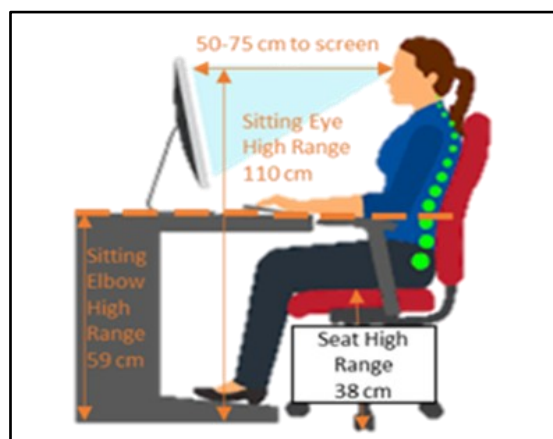


Fig. 2. Workstation equipped with an adjustable desk, ergonomic chair, and standard computer system used by participants during tasks

2.3. Data Processing

After collecting the individual weights of the IEQ components, further analysis was conducted using the Best-Worst Method (BWM). The Best-Worst Method (BWM), originally proposed by Rezaei, is a tool designed for addressing multi-criteria decision-making (MCDM) problems (Correia et al., 2021; Gani et al., 2021). One of its key strengths lies in its adaptability and ability to incorporate the preferences of several decision-makers more effectively than many traditional MCDM techniques. Compared to methods like the AHP, BWM demonstrates greater consistency and demands significantly fewer pairwise comparisons (Mohammadrezai et al., 2021). AHP involves constructing a comparison matrix that evaluates the relative importance of every criterion pair. However, the complexity of this approach and inherent human cognitive limitations often lead to inconsistencies in the resulting comparison matrix (Hager et al., 2024; Kazibudzki, 2021; Sithi et al., 2025). The following are the steps of the BWM:

1. Determine the criteria for supplier evaluation

The determination of these criteria is based on the assessment of the Decision-Maker (DM). DM will determine what criteria are used in the assessment and evaluation of suppliers $\{c_1, c_2, \dots, c_n\}$.

2. Determining the best and worst criteria

The determination of the best and worst criteria is carried out by the DM. The DM will determine the best criteria (the most important, most primary, and most appropriate criteria) and the worst criteria (the least important, least primary criteria) based on the criteria that have been determined in stage 1. Determining the Best-to-Others (BO) and Others-to-Worst (OW) pairwise comparison matrices. Decision-Maker will provide an assessment of the best criteria against other criteria using a scale of 1 to 9, then the more important the criteria, the higher the score, while the less important the criteria, the lower the score. In the same way, DM will provide an assessment of other criteria against the worst criteria. The results of the BO and OW pairwise comparison matrices can be expressed as seen in Eq. (1) and Eq. (2):

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn}) \quad (1)$$

Where a_{Bj} indicates the superiority of the best criteria B compared to other criteria j , and $a_{BB} = 1$.

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW}) \quad (2)$$

3. Determining the weight of the criteria ($W_1^*, W_2^*, \dots, W_n^*$)

The weights for each criterion are derived through a linear programming (LP) formulation, utilizing the pairwise comparison matrices from both the BO and OW evaluations. Different maximization minimization between $\left\{ \left| \frac{W_j}{W_w} - a_{jw} \right|, \left| \frac{W_B}{W_j} - a_{Bj} \right| \right\}$ indicates the presence of an error minimization distance, which is incorporated into the subsequent model formulation as seen in Eq. (3):

$$\begin{aligned} \text{Min max}_j & \left\{ \left| \frac{W_j}{W_w} - a_{jw} \right|, \left| \frac{W_B}{W_j} - a_{Bj} \right| \right\} \\ \text{s.t.} & \\ & \sum_j W_j = 1 \\ & W_j \geq 0 \quad \text{for all } j \end{aligned} \quad (3)$$

Eq. (4) represents a min-max optimization objective, which can be reformulated into the corresponding linear programming model as follows:

$$\begin{aligned} \text{min } & \xi \\ \text{s.t.} & \\ & \left| \frac{W_j}{W_w} - a_{jw} \right| \leq \xi \quad \text{for all } j \\ & \left| \frac{W_B}{W_j} - a_{Bj} \right| \leq \xi \quad \text{for all } j \\ & \sum_j W_j = 1 \\ & W_j \geq 0 \quad \text{for all } j \end{aligned} \quad (4)$$

After solving the equation above, the optimal weight value is obtained ($W_1^*, W_2^*, \dots, W_n^*$) and ξ^*

4. Determining Consistency Ratio

After getting the final result, the level of consistency towards the comparison can be determined. The consistency ratio towards the BWM result can be determined by the value of ξ^* and is related to the consistency index as shown in Table 1 and Eq. (5) below:

$$\text{Consistency Ratio} = \frac{\xi^*}{\text{Consistency Index}} \quad (5)$$

Table 1. BWM Consistency Index

<i>a_{BW}</i>	1	2	3	4	5	6	7	8	9
CI	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

5. Sensitivity Analysis

Sensitivity tests are necessary to ascertain the robustness of the study's chosen elements because BMW is an MCDM approach (Hsu et al., 2021). To verify the durability of the suggested BWM-based MCDM model, a sensitivity analysis was done. Stated differently, sensitivity analysis need to be carried out to track modifications in outcomes while accounting for various circumstances (Ecer, 2021). This is accomplished by examining the stability of the findings in relation to the degree of disagreement among differing perspectives and the internal consistency of the opinions of the people gathered (Kavta & Goswami, 2021). It is vital to ascertain the initial variation ratio's value prior to deciding how the weight of the criterion will vary. This may be done in the following ways as seen in Eq. (6):

$$y_k = \frac{\beta_k - \beta_k w_k}{1 - \beta_k w_k} \quad (6)$$

With y_k is the original ratio of variation prior to adjustment; β_k is the specified unit-based variation coefficient; w_k is the baseline weight assigned to the criterion undergoing change. And use the following formula to determine the value of the criterion weight that is affected by the change in the value of a criterion weight as seen in Eq. (7):

$$w'_n = \frac{w_n}{1 + (y_k - 1)w_k} \quad (7)$$

With w'_n is final weight of criteria that impact change; w_n is initial weights of criteria that impact changes; y_k is initial variation ratio; w_k is initial weight of criteria that have changed.

3. Results and Discussion

To find the ideal weights for each of the five IEQ components, the OW and BO pairwise comparison matrices must first be constructed. Using Microsoft Excel Solver software, the linear programming model in Eq. (4) is applied to the results of the Others-To-Worst and optimum-To-Others pairwise comparison matrices to get the ideal weights for the five IEQ components. Based on the computation findings, the ideal weights ($W_1^*, W_2^*, \dots, W_n^*$) and ξ^* of each primary criterion and sub-criteria are established. Once the final results are known, the consistency level for each of the five IEQ components may be determined. The consistency ratio value with respect to the BWM outcomes may be found by utilizing the consistency index Table 1 and ξ^* . Recapitulation of the Results of the Criteria Weight Calculation can be seen in the Table 2.

Table 2. Average of IEQ Components Weighting

IEQ factor	Average	Rank
Indoor Air Quality (IAQ) (A)	0.1000	5
Thermal Comfort (B)	0.2399	2
Lighting Quality (C)	0.1147	3
Acoustic Quality (D)	0.1095	4
Occupant Experience (E)	0.4359	1

It can be seen in Table 2 Recapitulation of the Results of the Calculation of the IEQ Weights, the IEQ components that have the highest value are Occupant Experience (E) with an average of 0.4359; then the Thermal Comfort (B) with an average of 0.2399 ranked 2nd; followed by Lighting Quality (C) with an average of 0.1147 ranked 3rd; Rank 4 is occupied by the Acoustic Quality (D) with an average of 0.1095; and finally rank 5 is occupied by Indoor Air Quality (IAQ) (A) with an average of 0.1000.

Table 3. (Advanced) Recapitulation of Calculation Results for IEQ Weighting

IEQ factor	Decision Maker									
	1	2	3	4	5	6	7	8	9	10
A	0.0698	0.0909	0.0909	0.0726	0.0838	0.0930	0.0954	0.0976	0.0996	0.0723
B	0.1163	0.1212	0.1212	0.2032	0.5028	0.1279	0.1527	0.1562	0.5228	0.3880
C	0.1163	0.1515	0.1515	0.1524	0.1341	0.1279	0.1272	0.1116	0.1162	0.0843
D	0.1163	0.1515	0.1515	0.1219	0.1117	0.1279	0.0972	0.0976	0.0871	0.0675
E	0.5814	0.4848	0.4848	0.4499	0.1676	0.5233	0.5275	0.5370	0.1743	0.3880

Table 3, presents the individual decision-maker weightings for each IEQ factor (columns 1–10). Higher values indicate greater relative importance assigned by that decision maker to the corresponding IEQ component.

Table 4. (Advanced 1) Recapitulation of Calculation Results for IEQ Weighting

IEQ factor	Decision Maker									
	11	12	13	14	15	16	17	18	19	20
A	0.1017	0.1077	0.1168	0.1212	0.0986	0.1213	0.1041	0.1212	0.1212	0.1102
B	0.1356	0.5385	0.1022	0.1061	0.5915	0.0944	0.0925	0.1061	0.5455	0.1102
C	0.1017	0.1231	0.1168	0.1061	0.0986	0.1061	0.1041	0.1061	0.1061	0.0964
D	0.1017	0.1077	0.1022	0.1212	0.1127	0.0944	0.1131	0.1212	0.1212	0.0992
E	0.5593	0.1231	0.5620	0.5455	0.0986	0.5838	0.5861	0.5455	0.1061	0.5840

Table 5. (Advanced 2) Recapitulation of Calculation Results for IEQ Weighting

IEQ factor	Decision Maker										Average
	21	22	23	24	25	26	27	28	29	30	
A	0.1168	0.1092	0.0986	0.1020	0.0955	0.0972	0.1000	0.0787	0.1007	0.1120	0.1000
B	0.5620	0.0868	0.0986	0.5170	0.0955	0.0972	0.6000	0.1137	0.0915	0.1008	0.2399
C	0.1022	0.0955	0.0986	0.1361	0.1273	0.1111	0.1000	0.1137	0.1030	0.1152	0.1147
D	0.1168	0.1092	0.1127	0.1088	0.1091	0.1111	0.1000	0.0995	0.0915	0.1008	0.1095
E	0.1022	0.5993	0.5915	0.1361	0.5727	0.5833	0.1000	0.5945	0.6133	0.5712	0.4359

Table 4 and Table 5 show the extended decision-maker weightings across the full sample (DM 11–30). These tables illustrate the variability among respondents and justify the aggregation reported in Table 2.

In addition, a sensitivity analysis was performed to evaluate how the model's outcomes respond to variations in its input parameters. In this study, the input factor that will be changed is the weight value of each criterion used so that it can be seen how much it changes the results of the best alternative order based on the calculation (BWM). The sensitivity analysis method used refers to the sensitivity

analysis by (Rouhani-Tazangi et al. 2023), where the weight change is based on the unitary variation ratio so that when one criterion weight value changes, the other criterion weight values will adjust to the change in the criterion weight value. This study uses values (β) 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 0.9; and 1 [Table 6](#).

Table 6. Changes in Weight of Each IEQ Components

IEQ Components	initial weight	β									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
		yk									
		0.0590	0.1236	0.1947	0.2733	0.3607	0.4583	0.5683	0.6929	0.8354	1.0000
A	0.1000	0.1696	0.1618	0.1541	0.1464	0.1387	0.1309	0.1232	0.1155	0.1077	0.1000
B	0.2399	0.4068	0.3882	0.3697	0.3512	0.3326	0.3141	0.2955	0.2770	0.2585	0.2399
C	0.1147	0.1944	0.1856	0.1767	0.1679	0.1590	0.1501	0.1413	0.1324	0.1235	0.1147
D	0.1095	0.1856	0.1771	0.1682	0.1603	0.1514	0.1435	0.1346	0.1267	0.1178	0.1095
E	0.4359	0.7390	0.7053	0.6717	0.6380	0.6043	0.5706	0.5369	0.5032	0.4696	0.4359

Table 7. The weighted rankings of the IEQ components were obtained through sensitivity analysis

β	Indoor Air Quality (IAQ)	Thermal Comfort	Lighting Quality	Acoustic Quality	Occupant Experience
0,1	4	1	2	3	5
0,2	5	1	3	4	2
0,3	5	1	3	4	2
0,4	5	2	3	4	1
0,5	5	2	3	4	1
0,6	5	2	3	4	1
0,7	5	2	3	4	1
0,8	5	2	3	4	1
0,9	5	2	3	4	1
1	5	2	3	4	1

[Table 7](#) presents the outcome of the sensitivity analysis weight ranking. The weight varies according to values (β), with starting points of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, and 1. [Table 7](#) displays the ranking of the other elements following the modifications in weight assigned to the most significant component, which is Process Integration. The final ranking of the factor was steady as there was no discernible shift in the ranking of the other factors, and the changes in the most significant factor fell between 0.1 and 0.9.

Given that BMW is a multi-criteria decision-making process, sensitivity analysis is required to ascertain the robustness of the variables used for this investigation. Sensitivity analysis may be used to track changes in high-weight factors between the ranges of 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 0.9; and 1 and document its impact on other factors. [Fig. 3](#) displays the findings from the sensitivity

analysis of the final BWM weights. The graphic shows that the final ranking remains constant when the high-weight factor's weight is changed at predetermined intervals.

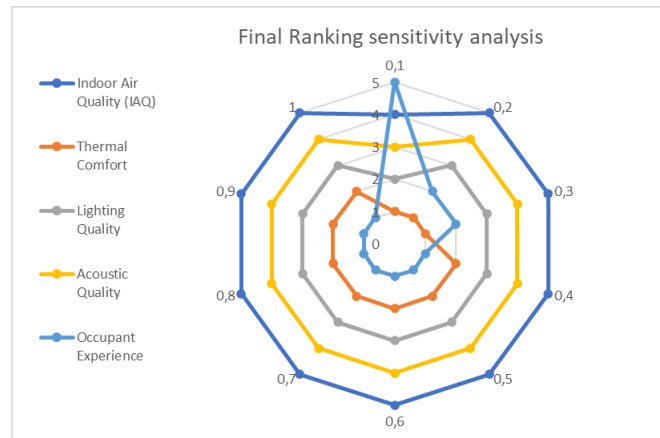


Fig. 3. Final ranking through sensitivity analysis

This study set out to address the problem of declining concentration, motivation, and productivity often associated with poor Indoor Environmental Quality (IEQ) in office environments. Previous research has shown that thermal comfort, air quality, lighting, and acoustics play a significant role in shaping workplace performance (Elnaklah et al., 2020; Kang et al., 2017; Liu et al., 2022). However, these studies largely relied on subjective survey data and often overlooked the role of occupant experience, particularly ergonomic aspects.

Using the Best-Worst Method (BWM), this research systematically quantified the relative importance of five IEQ components. The findings reveal that Occupant Experience is the most dominant factor, outweighing traditional elements such as air quality and lighting. This outcome highlights the importance of ergonomic interventions like adjustable desks, supportive chairs, and optimized layouts that reduce musculoskeletal strain and improve work efficiency. From a psychological perspective, ergonomically supportive environments promote comfort, reduce stress, and foster sustained concentration, aligning with theories in ergonomics and work psychology that emphasize the relationship between physical conditions and cognitive outcomes. These results both support and extend existing literature. Kang et al., (2017) found that lighting and acoustics significantly influenced concentration, while Elnaklah et al., (2020) emphasized thermal and air quality improvements in green office settings. Liu et al., (2022) linked low IEQ to reduced motivation and performance. While these studies highlighted key environmental dimensions, they did not systematically integrate occupant experience. The novelty of this study lies in demonstrating, through BWM and sensitivity analysis, that ergonomic improvements are not only relevant but critical determinants of productivity, thus expanding the conceptual framework of IEQ.

Methodologically, the use of BWM adds rigor by reducing inconsistency in pairwise comparisons compared to other decision-making models such as AHP. Sensitivity analysis further confirmed the robustness of results, ensuring that Occupant Experience consistently ranked first even under varying weight scenarios. From a practical standpoint, the findings provide important insights for modern office design. In open-plan offices, where noise and distractions are prevalent, prioritizing ergonomic solutions such as partitioned workstations, acoustic panels, and adjustable furniture can help offset environmental stressors. Conversely, in private offices where noise is less of a concern, thermal comfort, lighting quality, and personalized ergonomic setups become more crucial. For organizations, this means that IEQ strategies should not adopt a one-size-fits-all approach but instead adapt interventions to specific spatial configurations. Integrating ergonomic and environmental improvements across both open-plan and private office designs can significantly enhance worker well-being, reduce health complaints, and boost overall productivity.

4. Conclusion

This study highlights the significant impact of Indoor Environmental Quality (IEQ) on office worker performance by systematically analyzing five key components: Indoor Air Quality (IAQ), Thermal Comfort, Lighting Quality, Acoustic Quality, and Occupant Experience. The results demonstrate that Occupant Experience, particularly ergonomic improvements such as adjustable furniture and optimized workspace layouts, has the strongest influence on productivity, followed by Thermal Comfort, Lighting Quality, Acoustic Quality, and IAQ. The use of the Best-Worst Method (BWM) proved effective in weighting these factors, and sensitivity analysis confirmed the robustness of the findings. This research provides both academic and practical contributions. Academically, it expands the conceptual framework of IEQ by integrating Occupant Experience as a novel component in the BWM model. Practically, it offers evidence-based guidance for organizations and designers to prioritize ergonomic and environmental interventions in creating healthier and more productive office spaces. However, this study has several limitations. The data collection relied primarily on subjective surveys and simulated office conditions, which may not fully capture real-world variability. Furthermore, participant characteristics were limited to a relatively homogeneous group of young adults, which restricts generalizability to broader populations. Future research should address these limitations by incorporating objective measurements, such as air quality sensors, physiological stress biomarkers, and real-world performance indicators. Expanding participant demographics and workplace contexts will also strengthen the external validity of findings. Such approaches will enable more comprehensive and evidence-driven guidelines for designing optimal work environments.

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References

- Aswar, Suharto, Ravai, A., & Chaeriah, E. S. (2022). The Effect of Work Environment and Work Pressure on Job Satisfaction and the Impact on Employees Performance of West Jakarta DJP Regional Office. *Journal of Economics, Finance And Management Studies*, 05(03), 509–518. <https://doi.org/10.47191/jefms/v5-i3-08>
- Atef, N., Sabry, H., & Faggal, A. A. (2018). Argumentation for Impact of Indoor Environmental Quality on Users Performance: Online Self-assessment Questionnaire. *Engineering Research Journal*, 160(March 2023). <https://doi.org/10.21608/erj.2018.139569>
- Correia, L. M. A. de M., Da Silva, J. M. N., Leite, W. K. dos S., Lucas, R. E. C., & Colaco, G. A. (2021). A Multicriteria Decision Model To Rank Workstations In A Footwear Industry Based On A Fitradeoff - Ranking Method For Ergonomics Interventions. *Operational Research*, 22. <https://doi.org/10.1007/s12351-021-00671-0>
- Danza, L., Barozzi, B., Bellazzi, A., Belussi, L., Ghellere, M., Salamone, F., & Scamoni, F. (2020). A Weighting Procedure To Analyse The Indoor Environmental Quality Of A Zero-Energy Building. *Building and Environment*, 183, 107155. <https://doi.org/10.1016/j.buildenv.2020.107155>
- Delgado-saborit, J. M., Guercio, V., Gowers, A. M., Shaddick, G., Fox, N. C., & Love, S. (2021). A Critical Review Of The Epidemiological Evidence Of Effects Of Air Pollution On Dementia , Cognitive Function

- And Cognitive Decline In Adult Population. *Science of the Total Environment*, 757, 143734. <https://doi.org/10.1016/j.scitotenv.2020.143734>
- Di Blasio, S., Shtrepi, L., Puglisi, G. E., & Astolfi, A. (2019). A Cross-Sectional Survey On The Impact Of Irrelevant Speech Noise On Annoyance, Mental Health And Well-Being, Performance And Occupants' Behavior In Shared And Open-Plan Offices. *International Journal of Environmental Research and Public Health*, 16(2). <https://doi.org/10.3390/ijerph16020280>
- Duque, L., Costa, R., Dias, A., Pereira, L., Santos, J., & Antonio, N. (2020). New Ways of Working and the Physical Environment to Improve Employee Engagement. *Sustainability (Switzerland)*, 12(iii), 1–18.
- Ecer, F. (2021). Sustainability Assessment Of Existing Onshore Wind Plants In The Context Of Triple Bottom Line: A Best-Worst Method (BWM) Based MCDM Framework. *Environmental Science and Pollution Research*, 28(16), 19677–19693. <https://doi.org/10.1007/s11356-020-11940-4>
- Elnaklah, R., Fosas, D., & Natarajan, S. (2020). Indoor Environment Quality And Work Performance In Green Office Buildings In The Middle East. *Build Simul*, 13, 1043–1062. <https://doi.org/doi.org/10.1007/s12273-020-0695-1>
- Faez, E., Zakerian, S. A., Azam, K., Hancock, K., & Rosecrance, J. (2021). An Assessment of Ergonomics Climate and Its Association with Self-Reported Pain , Organizational Performance and Employee Well-Being. *International Journal of Enviromental Research and Public Health*, 18.
- Felgueiras, F., Mourao, Z., Moreira, A., & Gabriel, M. F. (2023). Indoor Environmental Quality In Offices And Risk Of Health And Productivity Complaints At Work: A Literature Review. *Journal of Hazardous Materials Advances*, 10(February). <https://doi.org/10.1016/j.hazadv.2023.100314>
- Gani, A., Asjad, M., Talib, F., Khan, Z. A., Noor, A., & Gani, A. (2021). Identification , Ranking And Prioritisation Of Vital Environmental Sustainability Indicators In Manufacturing Sector Using Pareto Analysis Cum Best-Worst Method Indicators In Manufacturing Sector Using Pareto Analysis Cum Best-Worst Method. *International Journal of Sustainable Engineering*, 14(3), 226–244. <https://doi.org/10.1080/19397038.2021.1889705>
- Gupta, R., Howard, A., & Zahiri, S. (2019). Investigating The Relationship Between Indoor Environment And Workplace Productivity In Naturally And Mechanically Ventilated Office Environments. *Building Services Engineering Research & Technology*, 41(3). <https://doi.org/10.1177/0143624419891568>
- Hager, P., Jungmann, F., Holland, R., Bhagat, K., Hubrecht, I., Knauer, M., Vielhauer, J., Makowski, M., Braren, R., & Kaissis, G. (2024). Evaluation and mitigation of the limitations of large language models in clinical. *Nature Medicine*, 30(September). <https://doi.org/10.1038/s41591-024-03097-1>
- Heidarimoghadam, R., Mohammadfam, I., & Babamiri, M. (2022). What Do The Different Ergonomic Interventions Accomplish In The Workplace? A Systematic Review. *International Journal of Occupational Safety and Ergonomics (JOSE)*, 28, 1–25. <https://doi.org/10.1080/10803548.2020.1811521>
- Hsu, T. H., Chen, C. H., & Liao, W. C. (2021). A Fuzzy MCDM Analytic Model for Building Customers' Brand Attachment Preference in Car Firms. *International Journal of Fuzzy Systems*, 23(7), 2270–2282. <https://doi.org/10.1007/s40815-021-01100-2>
- Kang, S., Ou, D., & Mak, C. M. (2017). The Impact Of Indoor Environmental Quality On Work Productivity In University Open-Plan Research Offices. *Building and Environment*, 124. <https://doi.org/10.1016/j.buildenv.2017.07.003>
- Kavta, K., & Goswami, A. K. (2021). A Methodological Framework For A Priori Selection Of Travel Demand Management Package Using Fuzzy MCDM Methods. *Transportation*, 48(6), 3059–3084. <https://doi.org/10.1007/s11116-020-10158-0>
- Kazibudzuki, P. T. (2021). On the Statistical Discrepancy and Affinity of Priority Vector Heuristics in Pairwise-Comparison-Based Methods. *Entropy*, 23(9).
- Kumar, G. R., & Bezawada, S. T. (2019). The Impact of Ergonomics on Employees Productivity in the Architectural Workplaces. *International Journal of Engineering and Advanced Technology*, 8958(5), 1122–1132. <https://doi.org/10.35940/ijeat.E1157.0585C19>

- Lan, L., Qian, X. L., Lian, Z. W., & Lin, Y. B. (2021). Local body cooling to improve sleep quality and thermal comfort in a hot environment. *Indoor Air*, January. <https://doi.org/10.1111/ina.12428>
- Liu, F., Chang-Richards, A., Wang, K. I.-K., & Dirks, K. N. (2022). Indoor environmental factors affecting the productivity of workers in office buildings Indoor environmental factors affecting the productivity of workers in office buildings. *Earth and Environmental Science*, 11(01). <https://doi.org/10.1088/1755-1315/1101/2/022001>
- Lou, H., & Ou, D. (2019). A Comparative Field Study Of Indoor Environmental Quality In Two Types Of Open-Plan Offices: Open-Plan Administrative Offices And Open-Plan Research Offices. *Building and Environment*, 148(August 2018), 394–404. <https://doi.org/10.1016/j.buildenv.2018.11.022>
- Luo, W., Kramer, R., de Kort, Y., Rense, P., & van Marken Lichtenbelt, W. (2022). The Effects Of A Novel Personal Comfort System On Thermal Comfort, Physiology And Perceived Indoor Environmental Quality, And Its Health Implications - Stimulating Human Thermoregulation Without Compromising Thermal Comfort. *Indoor Air*, 32(1), 1–17. <https://doi.org/10.1111/ina.12951>
- Mohammadrezai, M., Sarlak, M. A., & Faghihi, A. (2021). Provide a Model to Evaluate the Productivity of knowledge Workers Using the Fuzzy Delphi Method and the Best-Worst Fuzzy Method: A Case Study of Knowledge-Based Companies). *Organizational Culture Management*, 19(2). <https://doi.org/10.22059/jomc.2021.311287.1008153>
- Porras-Salazar, J. A., Schiavon, S., Wargocki, P., Cheung, T., & Tham, K. W. (2021). Meta-analysis of 35 studies examining the effect of indoor temperature on office work performance. *Building and Environment*, 203, 108037. <https://doi.org/10.1016/j.buildenv.2021.108037>
- Sadick, A., Kpamma, Z. E., & Agyefi-mensah, S. (2020). Impact Of Indoor Environmental Quality On Job Satisfaction And Self-Reported Productivity Of University Employees In A Tropical African climate. *Building and Environment*, 107102. <https://doi.org/10.1016/j.buildenv.2020.107102>
- Sithi, S. S., Ara, M. A., Tahmid, A., Dhruho, A. T., Rony, A. H., & Shabur, M. A. (2025). Sustainable Supplier Selection In The Textile Industry Using Triple Bottom Line and SWARA - TOPSIS Approaches. *Discover Sustainability*, 6. <https://doi.org/10.1007/s43621-025-01206-9>
- Song, C., Duan, G., Wang, D., Liu, Y., Du, H., & Chen, G. (2021). Study On The Influence Of Air Velocity On Human Thermal Comfort Under Non-Uniform Thermal Environment. *Building and Environment*, 196(March). <https://doi.org/10.1016/j.buildenv.2021.107808>
- Song, Y., Mao, F., & Liu, Q. (2021). Human Comfort in Indoor Environment: A Review on Assessment Criteria Data Collection and Data Analysis Methods. *IEEE Access*, 7, 119774–119786. <https://doi.org/10.1109/ACCESS.2019.2937320>
- Sun, C., Lian, Z., & Lan, L. (2021). Work Performance In Relation To Lighting Environment In Office Buildings. *Indoor and Built Environment*, 1(1), 1–19. <https://doi.org/10.1177/1420326X18820089>
- Thach, T. Q., Mahirah, D., Sauter, C., Roberts, A. C., Dunleavy, G., Nazeha, N., Rykov, Y., Zhang, Y., Christopoulos, G. I., Soh, C. K., & Car, J. (2020). Associations Of Perceived Indoor Environmental Quality With Stress In The Workplace. *Indoor Air*, 30(6), 1166–1177. <https://doi.org/10.1111/ina.12696>
- Udanarti, N., & Kasmir. (2022). The Effect of Work Environment and Work Motivation on Employee Performance through Workload on Bpjs Health Employees Prima Branch Office. *Journal of Business and Management Studies*, 4, 334–342. <https://doi.org/10.32996/jbms>
- Zhang, F., de Dear, R., & Hancock, P. (2019). Effects Of Moderate Thermal Environments On Cognitive Performance: A Multidisciplinary Review. *Applied Energy*, 236(July 2018), 760–777. <https://doi.org/10.1016/j.apenergy.2018.12.005>