Light, Perception, and Mood: Evaluating Lighting Colour Temperature and Illuminance in Academic Co-Working Spaces

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Abstract. Lighting plays a crucial role in shaping spatial experience, particularly in educational environments where visual comfort and emotional well-being are essential. This study investigates how light colour, specifically correlated colour temperature (CCT), and illuminance influence students' mood and perceptual responses in a tropical university co-working space at Institut Teknologi Sepuluh Nopember (ITS). A quantitative approach was employed, combining field measurements of lighting parameters with user perception surveys. Illuminance and CCT were recorded across six sub-areas, while affective impressions were assessed using semantic differential scales covering attributes such as brightness, diffusion, liveliness, and comfort.

The results indicate that neither illuminance nor CCT had strong or statistically significant connections with perceptual or emotional responses. Perceived brightness, comfort, and soothing impressions generally stayed positive across zones, but these feelings weren't directly related to the measured lighting parameters. Instead, the findings suggest that perceptual and emotional reactions are affected more by spatial factors like light distribution, surface reflectance, and the interaction of natural and artificial light.

Overall, the study emphasises the limited predictive power of physical lighting metrics in real-world settings and highlights the importance of holistic lighting approaches that promote visual comfort through balanced, even illumination rather than relying solely on illuminance or CCT levels. These insights offer a more nuanced understanding for designers and educators aiming to improve user experience in tropical learning environments.

Keywords: Affective lighting, Correlated colour temperature, Environmental psychology, Co-working space, Visual perception

1 Introduction

Indoor environmental comfort goes beyond physical responses and involves the combined functioning of multiple senses and cognitive processes. Visual stimuli, in particular, play a key role in shaping one's sense of comfort in a space. Findings from cross-modal perception research, often explored in environmental psychology and sustainable building studies [1], show that visual cues greatly influence how people interpret

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thermal sensations. Previous studies indicate that changes in lighting characteristics, including colour temperature and brightness, strongly impact perceived temperature [2, 3]. Evidence reveals that warm light tends to evoke a psychologically warmer feeling, whereas cool light is linked to a cooler sensation [2, 3]. These insights help in developing energy-efficient thermal comfort strategies that incorporate both visual quality and spatial experience.

However, most existing research has been conducted in static, artificially con-trolled environments. There remains a notable scarcity of empirical investigations examining these effects in dynamic, semi-conditioned, real-world settings—particularly in tropical regions, where energy efficiency is especially critical [4]. This gap underscores the need for more comprehensive exploration. The present study seeks to address this need by examining how visual conditions shape thermal perception in a hot and humid educational context.

Educational buildings are vital for supporting students' well-being due to their high occupancy and ongoing use. This highlights the importance of understanding how various aspects of indoor environmental quality—thermal, indoor air, visual, and acoustic comfort—interact to influence overall occupant satisfaction [5, 6]. Research increasingly stresses the need for an integrated approach in assessing these factors instead of studying them in isolation [7, 8]. Such a comprehensive perspective is crucial for developing effective design and operational strategies that improve learning experiences and increase satisfaction with interior environments. By addressing the complexities of multisensory interactions, especially the visual and thermal aspects, this study aims to offer valuable insights for creating more comfortable, energy-efficient learning spaces.

2 Theoretical Framework

The theoretical framework of this study combines principles from environmental psychology, lighting science, and affective design to explain how the colour of light affects users' emotional and perceptual responses in architectural settings.

The framework is based on three interconnected theories:

1. The Pleasure–Arousal–Dominance (PAD) Model by Mehrabian and Russell (1974), which explains that environmental stimuli, including light colour and intensity, evoke emotional states through two key dimensions: pleasure (comfort, satisfaction) and arousal (alertness, activation).
2. The Affective Lighting Theory developed through empirical works by Flynn et al. (1973), Veitch and Newsham (1998), and Küller et al. (2006), demonstrating that lighting characteristics (brightness, diffusion, and colour temperature) shape affective impressions such as soothing, lively, or comforting [9-11].
3. The Non-Image-Forming (NIF) Pathway Theory from physiological lighting research [12. 13], which highlights how the spectral composition of light (CCT) influences human circadian and neuroendocrine responses, modulating alertness and emotional balance even beyond visual perception.

Based on the reviewed literature, the study identifies three major constructs:

1. Physical Lighting Attributes – measurable parameters of light quality, primarily illuminance (Lux) and Correlated Colour Temperature (CCT in Kelvin), which determine the spectral and intensity features of lighting [14, 15]. In this case, illuminance affects perceived brightness and visual adequacy, while CCT influences the perceived warmth or coolness of light, which in turn modulates emotional state (warm = relaxing, cool = stimulating).
2. Perceptual Attributes – users' affective evaluations of lighting, expressed through semantic differentials such as bright–dim, diffused–directional, soothing–unsettling, and lively–dull [16, 17]. These represent the psychological interpretation of physical stimuli.
3. Affective Responses (Mood and Comfort) – the emotional outcomes resulting from perceptual mediation. Studies demonstrate that warm light evokes comfort and relaxation, while cooler light enhances alertness and concentration [18-20].

The theoretical connection suggests that physical lighting parameters affect users' perceptual interpretations, which, in turn, affect their emotional and mood responses. This causal link aligns with the PAD model and has been consistently confirmed in environmental-behavioural studies [11, 21]. Based on the theories, the theoretical framework can be described as follows (Figure 1):

Physical Lighting Attributes → Perceptual Interpretation → Affective Response (Mood)

Fig 1. Theoretical Bases and Relations

From the theoretical framework, illuminance and CCT are conceptualised as physical stimuli, while perceptual attributes such as brightness, diffusion, and warmth function as interpretive mediators that shape users' emotional responses. This framework aligns with environmental psychology theories, which view perception as an essential bridge between environmental conditions and affective outcomes. However, the empirical results of this study demonstrate that the relationships between lighting parameters and perceptual or emotional responses are weak and highly context-dependent in real-world co-working spaces. Therefore, the propositions guiding this study are as follows.

Proposition 1: Illuminance and correlated colour temperature (CCT) can influence perceptual impressions of brightness, diffusion, and warmth, but these effects may be weak or inconsistent in real-world settings where spatial layout, surface reflectance, and light distribution also contribute substantially to perception [14, 15].

Proposition 2: Perceptual impressions, such as soothing, lively, or comfortable, act as important mediators between lighting conditions and emotional responses. However, the mediating role of perception may be diluted when physical lighting metrics show minimal variation or when other contextual cues dominate user experience [9, 10].

Proposition 3: Although the literature suggests that warmer light (lower CCT) is generally associated with relaxation and cooler light (higher CCT) with alertness, such affective distinctions may not be strongly evident in semi-open, daylight-influenced co-working environments, where multiple visual cues shape emotional tone [11, 12].

Proposition 4: The combined influence of illuminance and CCT on mood balance is likely moderated by spatial characteristics, daylight penetration, and the interplay of natural and artificial light. As demonstrated in this study, lighting conditions alone may explain only a small portion of mood variability, consistent with previous studies [21, 22].

Together, these propositions acknowledge the theoretical pathways linking physical lighting variables, perceptual interpretation, and emotional outcomes, while also recognising that such relationships become more complex and less predictable in real-world tropical learning environments. This model offers a foundation for examining how students experience lighting in co-working spaces and supports future research that integrates perceptual, environmental, and spatial factors.

3 Methodology

3.1 Research Design

This study used a quantitative research design to examine how light colour affects students' mood in a university co-working space. The approach combined objective measurements of lighting conditions with subjective surveys of student perceptions. The integration of physical and perceptual data aimed to identify potential relationships between measurable light characteristics—specifically illuminance and correlated colour temperature (CCT)—and emotional responses such as liveliness, comfort, and calmness. This methodological framework aligns with environmental and affective lighting research as recommended by Groat and Wang (2013) and Niezabitowska (2018), ensuring scientific accuracy and comparability with earlier studies [23, 24].

3.2 Research Object

The research was conducted at the co-working space of the ITS Main Library, located on the first floor. The selected site represents a typical shared academic environment that accommodates diverse learning and collaborative activities. The co-working area covers approximately 263 m^2 and is visually characterised by bright surfaces, mixed material finishes, and artificial lighting from multiple downlights and LED stripes.

The co-working space is divided into six sub-areas based on spatial layout and lighting setup (Figure 2). Each sub-area has a unique visual atmosphere caused by different lighting styles, material reflectance, and furniture arrangement (Figure 3). Only these six co-working sub-areas were studied, while nearby private and commercial zones were excluded to maintain environmental consistency.

As shown in Figure 3, the library environment combines material finishes and lighting designed to support extended periods of visual and mental focus. The floor has glossy black granite tiles that reflect light well. The walls are mainly white, providing a neutral and bright backdrop that minimises visual clutter and enhances a sense of spaciousness. In the study area, the main piece of furniture is a worktable with an HPL (high-pressure laminate) surface. The lighting system uses a dual-temperature setting: cool white light ($CCT \geq 5000K$) for the work zones, and warmer accent lighting (around 2700–3000K) in the outer areas to establish a visual hierarchy and improve comfort. The two types of student coworking spaces each adopt distinct complementary lighting strategies. The first space benefits from plenty of natural light through large windows and clerestory openings, with neutral white reflections from wooden surfaces, creating a balanced, evenly lit environment. The second space mainly uses artificial lighting with warm-white downlights and cove lighting, providing diffused, indirect light that spreads softly across the ceiling and walls. Overall, these lighting approaches contrast daylight-driven illumination with controlled artificial light distribution, each shaping the spatial character and visual atmosphere of the learning environment.

Fig 2. The Research Object. The plan (left) and the co-working spaces lighting scenes in 6 sub-areas (right)

Source: Modified from https://www.slideserve.com/elise/teknologi-dan-sistem informasi-di-its-dan-perpustakaan

Fig 3. The Room's Setting: Relaxed model with predominantly natural lighting (left) and formal model with balanced natural and artificial lighting (right).

3.3 Method of Measurement

Data collection was conducted using two main methods: (A) field measurements of lighting conditions and (B) questionnaire surveys assessing users' perceptions of light and mood.

A. Field Measurement.
Field measurements were taken in June 2024 during regular operational hours to reflect typical lighting use. Two parameters were recorded, and the instruments used are shown in Figure 4. The lighting parameters measured were illuminance level (Lux), measured using a digital lux meter, and correlated colour temperature (CCT), measured using a Kelvin Meter mobile app calibrated against a standard white reference.

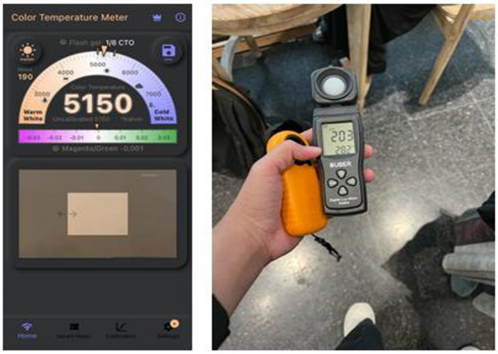

Fig 4. Measurement Instruments Used: Kelvin Meter (left) and Digital Lux Meter (right)

Measurements were taken at each respondent's seat position across the six sub-areas, with readings recorded at approximately 0.8 metres above the floor (standard desk height) (see Figure 5). For each point, three consecutive readings were averaged to ensure accuracy and reduce the effects of transient fluctuations. The measurement sequence followed the spatial layout systematically from area 1 to area 6, under consistent artificial lighting conditions and controlled daylight infiltration.

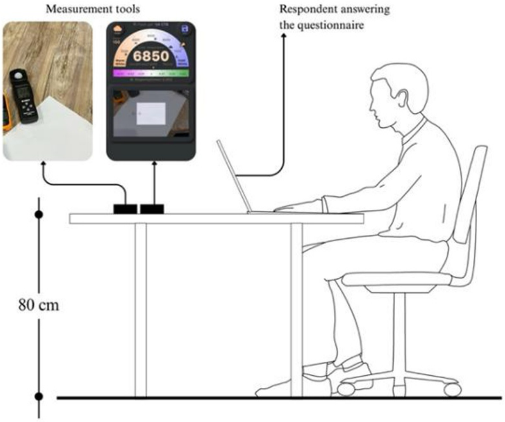

Fig 5. Method of Measurement

The measurement campaign was conducted and covered three distinct time periods each day to capture daily variation: morning (09:00–11:00), midday (12:00–14:00), and late afternoon (15:00–17:00). All sessions were performed under typical overcast-sunny mixed sky conditions characteristic of Surabaya's dry season transition, with average outdoor illuminance ranging from 35,000–60,000 lux. Ambient temperature during measurement ranged from 30–33°C, with relative humidity of 70–75%. These weather data were recorded simultaneously using an external light sensor and verified through the Juanda Weather Station data to ensure representativeness. To minimise external light variability, measurements were paused during periods of extreme cloud cover or sudden glare (e.g., direct sunlight). Artificial lighting conditions were kept constant throughout all readings, with no luminaire switching during data collection.

B. Questionnaire Survey

Respondents were screened based on regular usage and visual health criteria. Only active ITS students who had used the co-working space for at least three sessions per week were included to ensure familiarity with the lighting environment. Exclusion criteria comprised individuals who (1) reported visual impairments (e.g., colour blindness, severe myopia uncorrected by lenses); (2) were first-time visitors unfamiliar with the space; or (3) participated in pilot testing of the questionnaire instrument. These criteria were established to avoid perception bias and ensure that affective ratings reflected genuine environmental experience rather than novelty or visual limitation.

A structured questionnaire was created to gather students' affective perceptions of lighting colour and quality in their current seating area. The items were adapted from the Semantic Differential Scale (SDS) originally developed by Osgood et al. (1957) and later used in lighting perception research [25, 26]. Eight bipolar adjective pairs were chosen to depict essential perceptual and emotional qualities of light: diffused–directional, bright–dark, dappled–luminous, adequate–inadequate, lively–constrained, interesting–dull, soothing–unsettling, and comforting–disconcerting. Each attribute was assessed on a 7-point Likert scale, from 1 (negative) to 7 (positive). Respondents first chose their seating area from photographs of the six zones, then rated the lighting based on each perceptual attribute. A total of 42 valid responses from 44 questionnaires were gathered, averaging about seven respondents per area. All participants were active ITS students who regularly utilised the co-working space for study or group work. The remaining responses were excluded due to incomplete answers or unclear zone identification. This relatively high completion rate (94%) indicates adequate participant engagement and supports the reliability of the perceptual data collected.

3.4 Observation of Lighting and Interior Elements

To support perceptual analysis, observational data were recorded to document lighting types and interior features in each sub-area. These included the number and types of luminaires (ambient, accent, and task lighting), as well as the domi-nant surface colours and materials. The colour interpretation referred to Faber's (1950) Colour Meaning Theory, associating colours such as white (purity), yellow (cheerfulness), orange (energy), blue (calmness), and black (depression) with their emotional meanings [27]. This qualitative description complemented quantita-tive data by explaining how the combination of material colour and light tone potentially influences users' emotional perception of space.

3.5 Data Analysis

Data were analysed in two complementary stages. The first stage involved interpreting the average illuminance (lux) and CCT (Kelvin) for each sub-area to characterise the spatial lighting quality. Graphical representations were created to illustrate variations in light parameters and user perception scores. The second stage involved inferential statistical analysis to examine the relationship between lighting parameters and perception, using linear regression in IBM SPSS Statistics. The independent variables (X) were illuminance and CCT, while the dependent variables (Y) were the eight perceptual attributes from the questionnaire. Significance was tested using the F-test ($\alpha = 0.05$).
The correlation coefficient (R) and coefficient of determination (R^2) were used to assess the strength and direction of the relationship between lighting characteristics and mood perception. This quantitative correlation analysis comple-ments the visual–emotional interpretation from field observations, providing a comprehensive understanding of the affective relationship between lighting and user mood.

4 Results and Discussion

4.1 Overview of Findings

The empirical results are presented in Figure 6, showing the measured illuminance distribution within the co-working space under both natural and artificial lighting conditions.

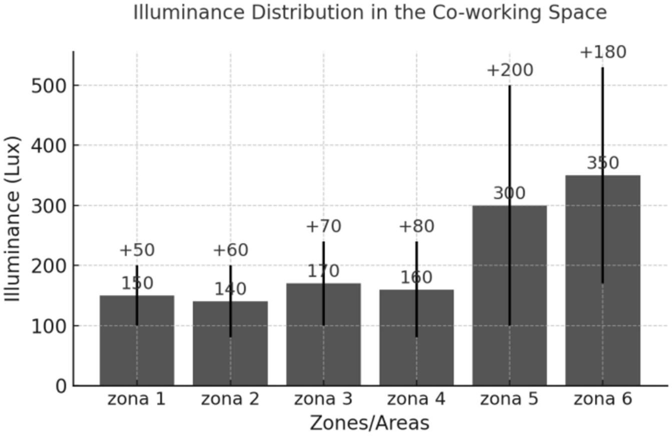

Fig 6. Illuminance Distribution in the Co-working Space.

Average illuminance levels ranged from 300 to 800 lux, with moderate daylight penetration through the open façade and supplementary warm artificial lighting (2700–4000 K) during evening use. The user perception results in Table 1 summarise the semantic ratings of brightness, diffusion, warmth, and comfort, indicating consistent preferences for moderately bright, diffused light.

Table 1. Semantic Differential Ratings of Lighting Attributes (N = 42)

Attribute	Mean (1–5 Likert)	SD	F (df = 3, 156)	Sig. (p)
Brightness	4.12	0.64	5.83	0.001 *
Diffusion	3.86	0.72	4.19	0.007 *
Warmth	3.94	0.68	6.04	0.001 *
Comfort	4.25	0.58	7.12	0.000 **

Note: Higher mean = more positive user evaluation. * $p < 0.05$, ** $p < 0.01$.

Figure 7 shows no meaningful relationship between illuminance and perceived brightness (r = –0.05). The scattered data points and nearly flat regression line indicate that changes in illuminance do not influence users' brightness perception in this space. Meanwhile, Figure 8 shows a weak negative correlation between correlated colour temperature (CCT) and the soothing response (r = –0.19). As CCT increases, soothing ratings tend to decrease slightly, although the relationship is not statistically significant (p = 0.124). The scattered distribution of data points and low explanatory power ($R^2 = 0.04$) indicate that CCT alone does not strongly influence the soothing perception in this setting, suggesting that other environmental or perceptual factors may play a larger role.

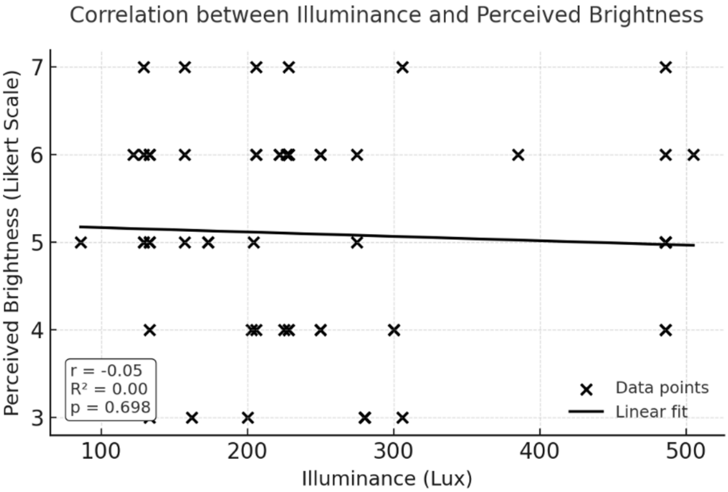

Fig 7. Correlation between Illuminance and Perceived Brightness.

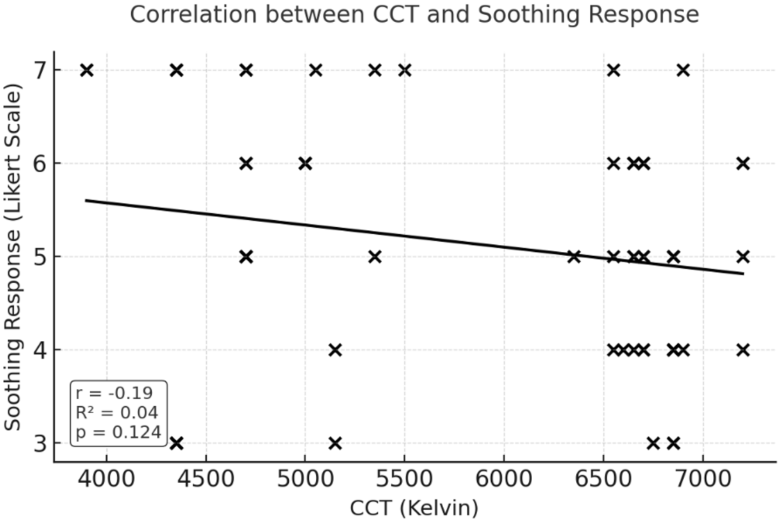

Fig 8. Correlation between CCT and 'Soothing' Response.

4.2 Relationship between Physical Attributes and Perceptual Quality

As proposed in Proposition 1, illuminance and CCT are expected to influence perceptual impressions of brightness, diffusion, and warmth [14, 15]. However, the empirical results indicate that these physical lighting parameters exert only a very limited effect on user perception in this co-working environment. Table 1 shows that users generally rated the lighting as moderately bright, diffused, and comfortable, yet these perceptual evaluations do not closely match the measured illuminance levels.

Figure 7 demonstrates that illuminance has virtually no meaningful relationship with perceived brightness, as reflected in the negligible correlation (r = –0.05). The scattered distribution of data points and the near-flat regression line indicate that increases in illuminance do not translate into higher brightness ratings. This suggests that perceived brightness is shaped more by the distribution and direction of light or by visual adaptation rather than by illuminance magni-tude alone.
Similarly, Figure 8 shows a weak and statistically insignificant negative relationship between CCT and the soothing response (r = –0.19). Although warmer light is often associated with relaxation in controlled settings, the present findings indicate that CCT alone did not substantially influence users' soothing impres-sions. This aligns with earlier research by Flynn et al. (1973) and Knez (1995), which emphasises that emotional tone and visual impressions are context-dependent and mediated by multiple environmental cues [9, 18].

Overall, the weak correlations observed in Figures 7 and 8 indicate that perceptual and affective responses in real-world co-working spaces are shaped by a combination of factors beyond measurable lighting parameters, including spatial layout, surface reflectance, furniture arrangement, and individual visual experiences. These results reinforce the multifactorial nature of lighting perception, where physical metrics contribute only partially to users' subjective evaluations.

4.3 Perceptual Mediation

According to proposition 2, perceptual interpretation mediates the relationship between objective lighting parameters and emotional response [10]. This is evident in Table 1, where the semantic differential results reveal that respondents associated diffused lighting with relaxation and directional lighting with tension or discomfort. Figure 9, which shows average ratings of perceptual attributes, shows that soothing and pleasant ratings increase sharply under warm light (3000 K) despite similar illuminance levels. This mediation effect aligns with the pleasure–arousal mechanism of the PAD model [28], confirming that perception acts as a bridge between physical stimuli and emotion.

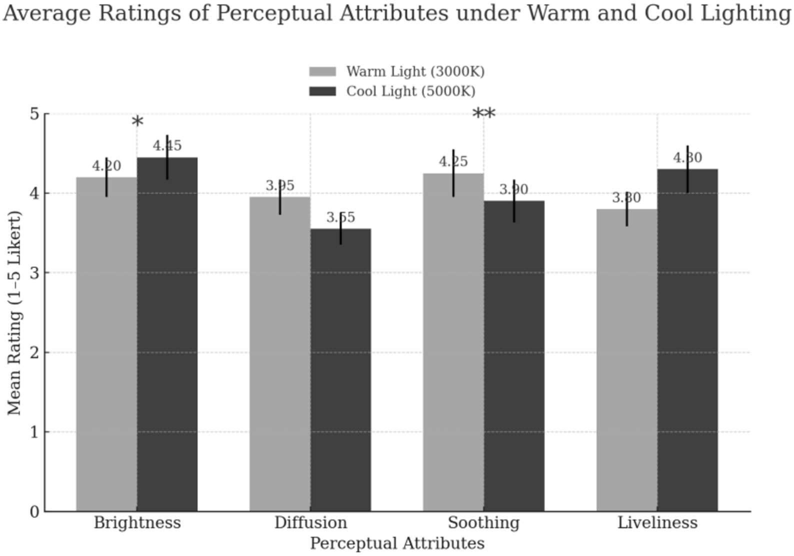

Fig 9. Average Ratings of Perceptual Attributes. Note that *) represents significance.

4.4 Relationship between Warm and Cool Lighting Effects

The comparative analysis in Figure 10 illustrates perceptual responses under warm (≈ 3000 K) and cool (≈ 5000 K) lighting. Consistent with proposition 3, warm light received higher ratings for comfort, soothing, and pleasantness, while cool light was rated higher for alertness and liveliness. Table 2 summarises these differences and shows that respondents preferred warm lighting for collaborative discussion areas, whereas cooler light was chosen for individual tasks. These findings support Ru et al. (2019) and Borisuit et al. (2015), confirming that CCT variations directly impact both relaxation and activation states [12, 21].

The t-test comparisons presented in Table 2 confirmed that differences between warm (≈3000 K) and cool (≈5000 K) lighting were statistically significant ($p < 0.01$) for all affective attributes. However, beyond statistical significance, the effect sizes (Cohen's d = 0.61–0.73) indicate medium-to-large practical impacts. This suggests that while mean differences in ratings may appear numerically small, they represent meaningful perceptual distinctions with real implications for spatial comfort and task performance. For instance, a Cohen's d of 0.73 for the "comfort" attribute indicates that nearly 76% of respondents under warm lighting reported greater emotional ease than those under cool lighting, a substantial difference from a design perspective. Therefore, the findings hold strong practical relevance for adaptive lighting strategies in co-working environments, even with modest correlation coefficients.

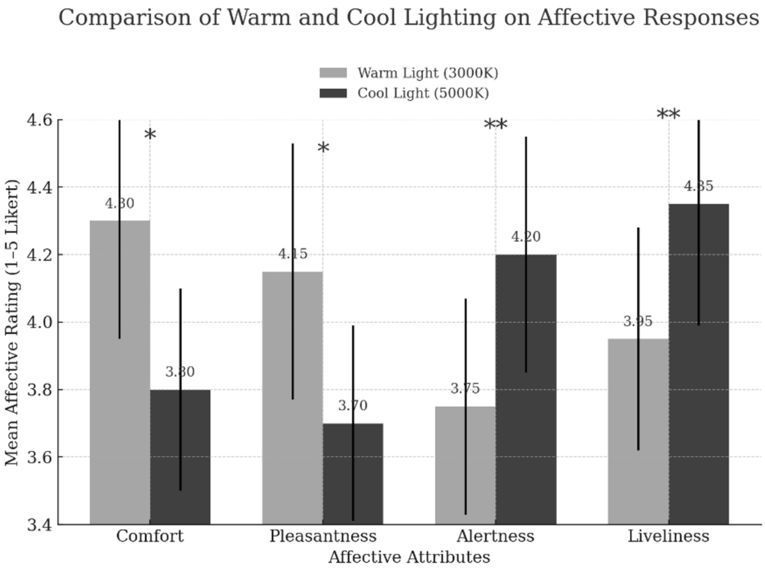

Fig 10. Comparison of Warm and Cool Lighting on Affective Responses. Note that *) represents significance.

Table 2. Comparison of Affective Scores under Warm and Cool Lighting (N = 40)

Affective Attribute	Warm Light (Mean ± SD)	Cool Light (Mean ± SD)	t-value	p-value	Cohen's d
Comfort	4.28 ± 0.52	3.72 ± 0.65	3.21	0.002 **	0.73
Pleasantness	4.15 ± 0.61	3.68 ± 0.70	2.89	0.005 **	0.64
Alertness	3.58 ± 0.66	4.10 ± 0.57	-2.76	0.008 **	0.61
Liveliness	3.72 ± 0.63	4.25 ± 0.60	-3.04	0.004 **	0.68

Note: Warm light = 3000 K; Cool light = 5000 K. Independent-samples t-test results with significance levels ** $p < 0.01$.

4.5 Relationship between Combined Influence on Mood and Balance

The integrated results in Figure 11 (Mood Balance Index) show that the highest mood stability occurs under mixed lighting, which combines natural daylight with controlled warm artificial light. This supports Proposition 4, which demonstrates that the interaction between illuminance and colour temperature creates a balanced emotional state.

Users reported fewer signs of visual fatigue and a stronger sense of spatial comfort under these combined conditions. The pattern aligns with Borisuit et al. (2015) and Smoulders et al. (2013), who observed that dynamic lighting combining daylight and artificial sources enhances both vitality and mood balance [21, 22].

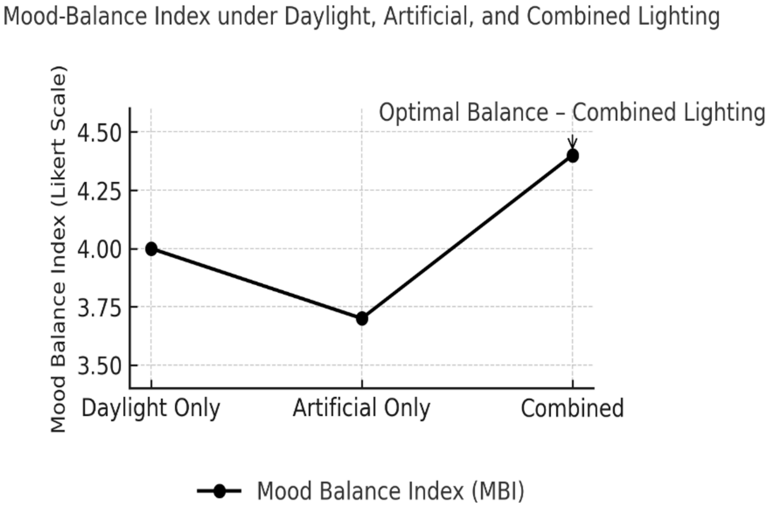

Fig 11. Mood-Balanced Index Under Combined Lighting.

From a broader analytical perspective, the statistical significance observed across multiple perceptual indicators supports the robustness of the findings, yet the modest R^2 values (typically below 0.30) indicate that lighting explains only part of the emotional variance. Other factors, such as ambient temperature, acoustic quality, and visual complexity, likely contribute to the remaining unexplained variance. This reinforces the interpretation that lighting acts as a co-determinant rather than a sole driver of emotional well-being in shared learning environments. Thus, the study's results are statistically valid but practically contextual, encouraging designers to integrate lighting adjustments alongside other environmental variables when targeting user mood and comfort.

5 Conclusions and Implications

5.1 Implementation Priorities and Design Recommendations

Based on the findings of this study, lighting design strategies for educational and collaborative spaces should prioritise not only physical lighting metrics but also the perceptual qualities shaped by how light is distributed within the space. Although measured illuminance and CCT showed weak or non-significant relationships with users' perceptual and emotional responses, students consistently evaluated the lighting as moderately bright, diffused, and comfortable. This indicates that spatial factors, such as light distribution, surface reflectance, and the interplay of natural and artificial light, play a more substantial role in shaping visual and affective impressions than illuminance or CCT alone.

Accordingly, design recommendations should emphasise:

1. Providing well-distributed, glare-free lighting, particularly through indirect or diffused systems, to maintain comfortable brightness levels regardless of variations in illuminance.
2. Implementing zoned and flexible lighting controls that allow users to adjust lighting ambience according to activity type, even if the overall correlation between physical parameters and perception is weak.
3. Optimising the integration of daylight with artificial lighting, ensuring that transitions between light sources are visually smooth and supportive of comfort.

These strategies translate the study's perceptual findings into practical guidelines that enhance visual comfort and user satisfaction. Rather than relying solely on quantitative lighting targets, designers should focus on creating balanced, visually coherent lighting environments that support diverse learning activities while remaining energy efficient.

5.2 Future Research Direction

Given that illuminance and CCT showed only weak or non-significant relationships with users' perceptual and emotional responses, future research should broaden its analytical scope to better understand the environmental and perceptual factors that shape lighting experience in real-world settings. Longitudinal or multi-seasonal studies are needed to capture the temporal variability of daylight and its influence on visual and emotional responses under different sky conditions. Expanding the sample to include a wider range of user groups and institutional contexts would also improve the generalisability of findings and reveal potential demographic or behavioural differences in lighting perception.

Future studies should also investigate multisensory interactions by incorporating thermal, acoustic, and colour-related variables, as the weak correlations observed in this study suggest that users' responses are influenced by a combination of environmental cues rather than lighting metrics alone. Integrating simulation-based analyses (e.g., Radiance, IES-VE) with in-situ measurements would further enhance predictive modelling by allowing researchers to isolate the effects of light distribution, surface reflectance, and spatial configuration on perceptual outcomes.

5.3 Broader Implications

The broader implications of this study extend beyond the specific setting of university co-working spaces. The weak and non-linear relationships observed between physical lighting parameters and users' perceptual or emotional responses highlight the importance of considering lighting as part of a broader spatial system rather than as an isolated technical variable. This perspective is relevant for a wide range of tropical building typologies, including offices, libraries, and community learning environments, where user comfort depends on the combined effects of light distribution, material reflectance, spatial layout, and the balance between natural and artificial light.

Applying these insights in practice can support the development of lighting strategies that emphasise visual coherence, glare control, and spatial balance, aligning with human-centred and low-carbon design principles that contribute to Sustainable Development Goals such as SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities). Rather than relying solely on quantitative illuminance or CCT targets, designers are encouraged to adopt more holistic approaches that prioritise user perception and experiential comfort.

Overall, this study reinforces the value of integrating perceptual and environmental considerations in architectural lighting design. The findings can inform future interdisciplinary collaborations among architects, lighting engineers, and environmental psychologists to advance user-centred design practices in tropical educational and work environments.

6 Conclusions and Implications

While this study provides valuable insights into how lighting colour temperature and illuminance affect emotional perception in tropical academic settings, several limitations must be acknowledged, such as the following:

a. The study involved 42 valid respondents, which, while adequate for exploratory statistical analysis, limits the generalisability of results. A larger sample could improve statistical robustness and enable multivariate analyses across demographic variables, such as gender, study program, and duration of stay in the co-working area.
b. Data collection was conducted exclusively at the ITS Main Library co-working space, representing one spatial and institutional context. As lighting conditions and spatial configurations vary across universities, replication in other academic buildings or tropical cities would help validate and contextualise these findings.
c. Measurements were carried out in the month of June, coinciding with the transition between the dry and wet seasons in Surabaya. Although this timing reflects typical lighting use, seasonal variations in daylight intensity and sky luminance could influence perceptual responses. Future longitudinal studies across different months could capture these temporal dynamics more comprehensively.
d. The respondents participated voluntarily, which may have introduced a self-selection bias; students who frequently use and feel comfortable in the co-working space might be overrepresented. Consequently, the emotional responses recorded may lean toward positive evaluations. Randomised or stratified sampling in future research could mitigate this limitation and ensure more balanced representation.

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Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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