



# Exploring the Cross-Modal Effect of Light Colour Temperature on Thermal Comfort in Student Co-Working Space

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**Abstract.** Environmental perception is influenced by multisensory interactions, where visual and thermal stimuli together shape human experience. This study examines cross-modal perception by investigating how changes in light colour and brightness impact thermal comfort in a collaborative student workspace within a tropical setting. Conducted in a semi-conditioned co-working area at the ITS Central Library, the study involved 42 participants. Subjective assessments of visual and thermal comfort were combined with environmental measurements, including correlated colour temperature (CCT), illuminance, air temperature, and humidity. Pearson correlation analysis revealed weak to moderate links between visual and thermal comfort votes (TCV). Notably, the colour comfort vote (CCV) showed the strongest relation, although it was not statistically significant. No significant correlations were found with thermal sensation votes (TSV). These results contribute to a growing understanding of how perceptions of indoor comfort are affected, especially in semi-conditioned tropical environments. The study underscores the potential for employing visual design strategies to improve low-energy comfort systems.

**Keywords:** Colour temperature, Cross-modal perception, Energy efficiency, Thermal comfort, Student co-working space.

## 1 Introduction

Indoor environmental comfort encompasses more than just how the human body reacts; it involves a complex interaction of all senses and mental faculties. Visual inputs play a key role in how comfortable a space feels. Cross-modal perception, studied in environmental psychology and sustainable building [1], indicates that vision significantly influences how people perceive heat. Previous studies reveal that different light qualities, such as colour temperature and intensity, notably impact how individuals perceive temperature [2, 3]. Research shows that warm lighting makes people feel psychologically warmer, while cool lighting induces a chilly sensation [2, 3]. These insights assist in designing energy-efficient thermal comfort solutions that balance visual appeal and interior experience.

Despite these findings, existing research has mainly focused on static and artificially controlled environments. A significant lack of empirical studies still exists regarding these effects in dynamic, semi-conditioned, real-world settings, especially in tropical climates where energy efficiency is crucial [4]. The gaps in literature highlight the need for further investigation. This study aims to address these gaps by exploring how visual conditions influence thermal perception, particularly in a hot and humid educational environment.

Educational buildings are vital in shaping students' well-being, as these facilities are used extensively. This highlights the need for a strong understanding of how different indoor environmental quality factors—such as thermal comfort, indoor air quality, visual comfort, and acoustic comfort—interact and influence overall occupant satisfaction [5, 6].

This research has emphasised the importance of adopting a holistic approach to understanding the interactions among these various parameters, rather than examining them in isolation [7, 8]. This broad perspective is essential for developing effective design and operational plans that enhance people's learning experiences and overall satisfaction with their interior spaces. This study aims to provide meaningful insights into creating more comfortable and energy-efficient learning environments by addressing the complexities of multisensory interactions, particularly regarding visual and thermal aspects in educational settings.

## 2 Literature Review

There are increasing studies in the literature that suggest visual stimuli plays a significant role in modulating thermal perception. For example, Iqbal et al. (2022) examined the comfort levels of people in naturally ventilated dwellings and how visual ambient variables influenced their comfort [9]. The results indicate that design choices can influence how people perceive temperature. Furthermore, Raj-put & Thomas (2023) discussed how integrating various passive design strategies, including lighting, can enhance thermal comfort through simulations [10]. Supporting this, Koutroumpi (2020) highlighted gaps in understanding occupant thermal comfort in naturally ventilated spaces, suggesting that visual elements can impact occupant thermal experiences [11].

However, most current research is carried out in controlled laboratory environments that replicate constant conditions. For example, Rahman et al. (2021) reviewed studies on thermal comfort in naturally ventilated public buildings and emphasised the need for validation in real-world scenarios characterised by natural variability [12]. This concern is also raised by Oleiwi and Mohamed (2022), who investigated passive design strategies and acknowledged the limitations imposed by controlled conditions, overlooking natural light variations and outdoor environmental fluctuations [13].

In tropical settings, where architectural solutions must deal with high temperatures and humidity, a significant gap exists in empirical research exploring how visual factors affect thermal perception in real-world environments. Mostly, studies in these regions have concentrated on thermal adaptation or passive cooling methods, often overlooking



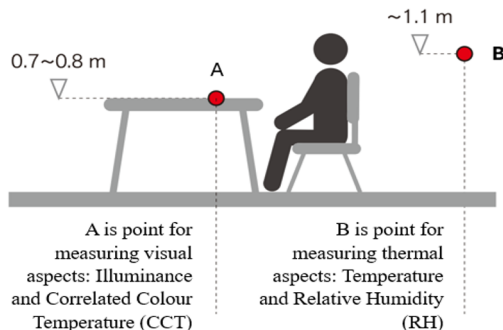


**Fig 2.** The Room's Setting: Relaxed Model (left) and Formal Model (right)

As shown in figure 2, the library environment features a combination of material finishes and lighting designed to encourage extended periods of visual and mental engagement. The floor is constructed from black granite tiles with a glossy finish, which enhances light reflection. The walls are predominantly white, providing a neutral, bright backdrop that minimises visual clutter and enhances the sense of space. The main furniture in the study area is a worktable with a High-Pressure Laminate (HPL) surface. The lighting system employs a dual-temperature approach, with cool white light (CCT  $\geq 5000\text{K}$ ) dedicated to the working areas. Meanwhile, warmer accent lighting (CCT approximately  $2700\text{--}3000\text{K}$ ) is used in outer zones to establish a visual hierarchy and promote spatial comfort.

### 3.1 Method of Measurement

Environmental data was collected alongside the perception survey to provide contextual variables. Illuminance and correlated colour temperature (CCT) were measured using a White Balance Kelvin Meter application. Meanwhile, air temperature and relative humidity were measured with a thermo-hygrometer (type SD583) (Table 1). Under typical usage conditions, measurements were taken at multiple points (Fig. 3) during regular operating hours (9:00–16:00). The data represents average values across time and locations, reflecting general ambient conditions.



**Fig 3.** Measurement Points

**Table 1.** Measurement instruments.

Variable	Instrument	Unit	Resolution	Accuracy
Air temperature	Thermo-hygrometer	°C	0.1	±1°C
Relative humidity	SD583	%	1	±5%
Correlated Color Temperature (CCT)	White Balance Kelvin Meter application	K	1	-
Illuminance (Lux)	Illuminance Meter	Lux	1	-

**3.2 Survey and Sampling**

Perceptual data were obtained through a structured questionnaire distributed to a randomly selected sample of 42 student users of the space. All participants were aged between 18 and 25 years and had spent at least 30 minutes in the study area prior to data collection. The survey was divided into two sections: visual perception and thermal perception.

**3.3 Variables and Questionnaire Design**

The questionnaire design was adapted from established sources in environmental psychology and thermal comfort literature [17, 18]. It is aimed at assessing participants’ subjective perceptions of indoor environmental conditions, with a specific focus on visual and thermal comfort.

**Table 2.** Visual and Thermal Perception Variables.

Variables	Parameters	Values
Visual perception (independent variable)	Lighting brightness comfort vote (LCV)	Uncomfortable (1) – Comfortable (7)
	Light colour comfort vote (CCV)	Uncomfortable (1) – Comfortable (7)
	Lighting cold-warm association (CWA)	Cold (1) – Warm (7)
	Lighting pleasantness vote (LPV)	Unpleasant (1) - Pleasant (7)
Thermal perception (dependent variable)	Light colour acceptability (CA)	Unacceptable (0) – Acceptable (100)
	Thermal sensation vote (TSV)	Cold (1) – Hot (7)
	Thermal comfort vote (TCV)	Very uncomfortable (1) – Comfortable (4)

Table 2 outlines the variables used to measure these perceptions. The visual perception section includes five items: Lighting Brightness Comfort Vote (LCV) and Light Colour Comfort Vote (CCV), which assess comfort with brightness and light colour on a 7-point scale from uncomfortable (1) to comfortable (7); Lighting Cold-Warm

Association (CWA), which measures how the lighting influences thermal impression, ranging from cold (1) to warm (7); Lighting Pleasantness Vote (LPV), which evaluates overall pleasantness of the lighting from unpleasant (1) to pleasant (7); and Colour Acceptability (CA), which asks participants to rate the acceptability of the light colour on a scale from unacceptable (0) to acceptable (100). The thermal perception section includes two items: Thermal Sensation Vote (TSV), measuring perceived temperature on a scale from cold (1) to hot (7), and Thermal Comfort Vote (TCV), which assesses comfort with the thermal environment using a 4-point scale from very uncomfortable (1) to comfortable (4). These indices are used to explore potential relationships between visual environmental factors and thermal perception in indoor spaces.

### **3.4 Data Analysis**

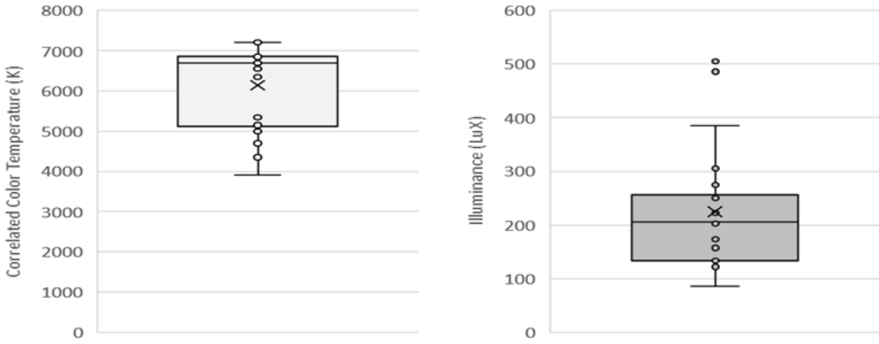
The main aim of the analysis was to determine whether visual perception variables significantly predicted thermal perception outcomes. Linear regression modelling assessed the relationship between independent variables (visual comfort indicators) and dependent variables (TSV and TCV). The strength of the association was evaluated using Pearson correlation and  $R^2$  values, with a significance level ( $\alpha$ ) set at 0.05. Scatterplots and regression lines were created to visualise trends. Statistical analysis was carried out using IBM SPSS Statistics 25 and Microsoft Excel to produce visualisations.

To ensure validity, multicollinearity between visual indicators was checked, and normality and linearity assumptions were verified before regression analysis. Although the sample size was limited, it aligns with preliminary perception studies in similar field contexts, providing a practical foundation for future, more extensive studies.

## **4 Results and Discussion**

### **4.1 Environmental Conditions: Light and Thermal Measurement Results**

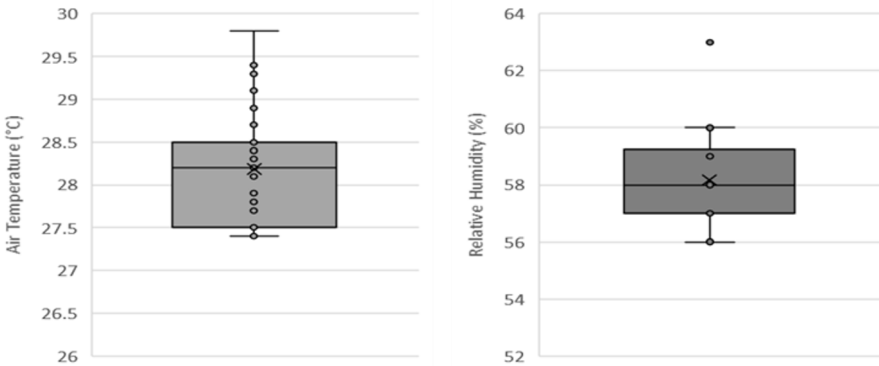
The collaborative student workspace in this study showed lighting with a highly correlated colour temperature (CCT). The average CCT recorded was  $6140 \pm 990$  K, with values ranging from 3900 K to 7200 K. Illuminance levels varied significantly, from 86 lux in dimmer areas to 505 lux in the brightest zones, with a mean of  $225 \pm 116$  lux. These conditions are typical of semi-conditioned tropical indoor settings, where artificial lighting often dominates or supplements daylight. Figure 3 displays the spatial distribution of CCT and illuminance in the observed room.



**Fig 4.** Measured CCT (left) and Illuminance (right) in the Student Collaborative Workspace

Such lighting conditions not only influence visual comfort but may also affect perceptual thermal comfort. Kulve et al. (2018) emphasise that poor lighting can worsen thermal discomfort, while better lighting can reduce it, even without changing the actual temperature [20]. This underscores the importance of visual perception in forming thermal impressions. Baniya et al. (2016) also support this by demonstrating that lighting with higher CCT (i.e., visually cooler light) often results in perceived cooling effects, whereas warmer lighting tends to increase the sensation of warmth [21].

Thermal measurements showed indoor air temperatures ranged from 27.4°C to 29.8°C, with an average of  $28.2 \pm 0.7^\circ\text{C}$ , while relative humidity was maintained at an average of  $58 \pm 1.7\%$  (Fig. 4). Although these values indicate a warm indoor environment, almost half of the participants reported feeling thermally comfortable. This gap between thermal sensation and thermal comfort highlights the possible role of cognitive and perceptual cues, in line with findings by Chinazzo et al. (2019), who demonstrated that visual stimuli—including daylight and artificial light—can expand the subjective thermal comfort zone [22]. Figure 5 displays the temperature and humidity ranges at each measurement point.

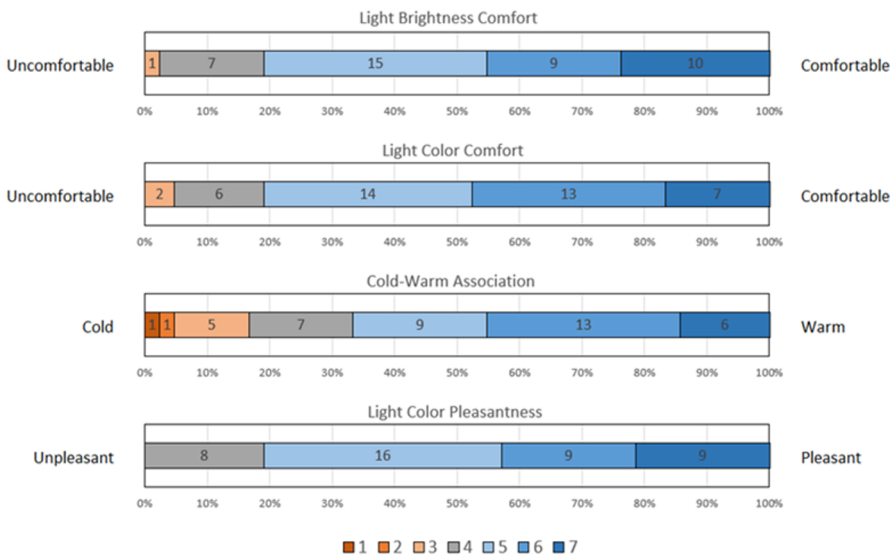


**Fig 5.** Measured Air Temperature (left) and Relative Humidity (right)

These observations suggest that although statistical correlations between visual and thermal comfort were not significant in this study, the theoretical basis remains strong. The presence of high-CCT lighting and moderate illuminance in the observed space supports the idea that visual cues, especially related to light colour, may affect thermal perception. This aligns with the concept of cross-modal perception, where one sensory input (light) influences the interpretation of another sensory dimension (temperature). In tropical architecture, where reducing energy use is crucial, this interaction can be strategically exploited. As Chinazzo et al. (2019) suggest, improving visual environments with perceptually cooler lighting can enhance thermal comfort, potentially lowering reliance on mechanical cooling [22]. Therefore, although the quantitative results in this study showed weak correlations, the qualitative implications are meaningful. Lighting design strategies may serve as a valuable psychological tool for supporting thermal adaptation in warm, humid learning settings.

## 4.2 Visual Perception Outcomes

Figure 6 displays survey results on visual perception. It shows that a large majority of participants viewed the lighting conditions in the collaborative workspace as favourable. Over 80% of respondents rated both lighting brightness comfort (LCV) and light colour comfort (CCV) as comfortable, while around 85% found the lighting to be pleasant (LPV). Additionally, more than 60% of respondents associated the ambient light with a warm sensation based on the Cold-Warm Association (CWA) scale. These findings demonstrate a strong positive response to the visual environment.



**Fig 6.** Visual Perception Survey Results.

The findings are also aligned with Chinazzo et al. (2021), who indicated that visual features of indoor spaces—including brightness and correlated colour temperature (CCT)—significantly affect occupants’ comfort and perceptual experience of the environment [19]. In learning and work areas, positive visual experiences not only improve spatial satisfaction but also boost cognitive engagement. Warm-toned lighting, in particular, has been demonstrated to promote emotional warmth and support a psychologically conducive environment for focused tasks [2].

The observed correlation between perceived colour comfort (CCV) and colour acceptability (CA) strengthens this relationship. As CA scores rose with higher CCV ratings, it shows that comfort with light colour is key to visual satisfaction (Fig. 7). This pattern aligns with earlier findings by Chinazzo et al. (2021), who demonstrated that lighting with specific spectral qualities and temperatures can positively impact perceptions of visual quality and environmental comfort [18].

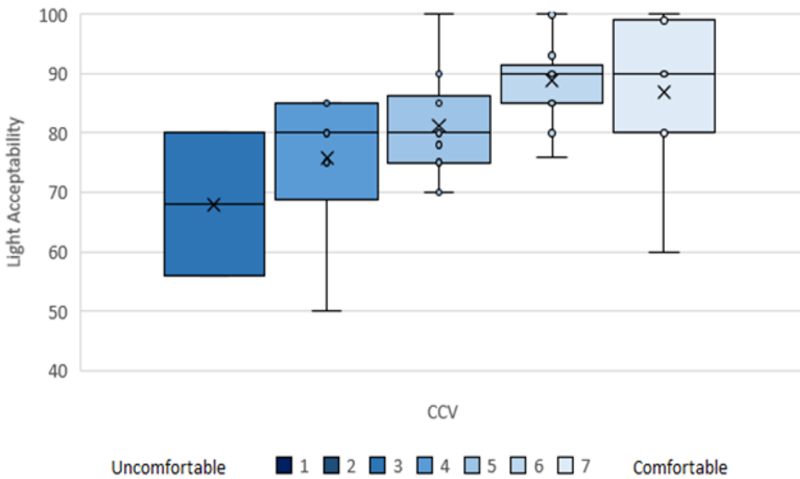


Fig 7. Light Colour Acceptability Measurements.

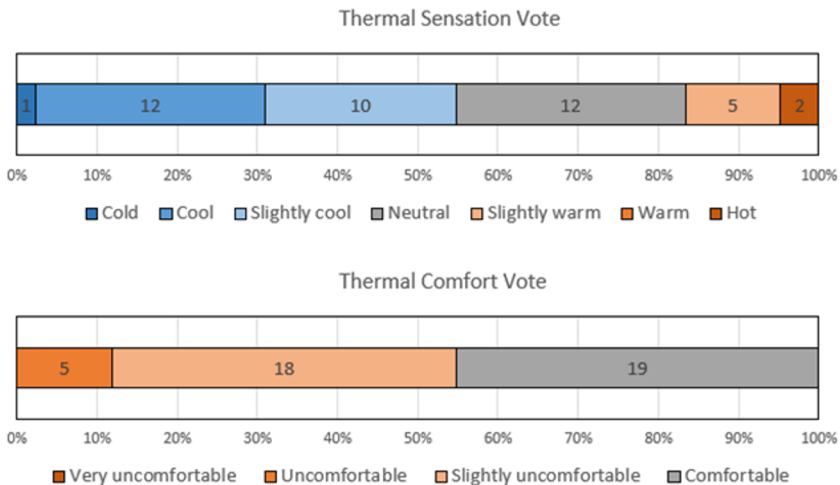
Furthermore, the finding that over 60% of participants perceived the light as warm (CWA) highlights the emotional and mental aspects of lighting experience. Lighting is judged not only by visual adequacy but also interpreted emotionally, creating impressions of warmth or coolness that go beyond physical measurements. This psychological view aligns with the theoretical model proposed by Omidvar and Brambilla (2021), which suggests that the colour temperature of light can influence both physiological responses and perceived thermal comfort simultaneously [20].

Although quantitative results in this study revealed only weak to moderate correlations between visual and thermal comfort indices, the qualitative interpretation suggests a deeper influence on understanding. Specifically, perceptions of brightness and colour contribute to a multisensory comfort experience, especially in tropical learning environments where mechanical cooling is not always desirable or feasible.

The implications of these findings are significant. In semi-conditioned tropical environments such as the library workspace observed in this study, lighting serves a dual purpose; it not only provides illumination but also influences emotional and sensory impressions that shape the experience of temperature and comfort. As Brambilla et al. (2020) note, properly designed lighting can act as a passive comfort strategy, extending thermal acceptability and reducing reliance on energy-intensive air conditioning systems [23]. Therefore, lighting design should go beyond meeting minimum illuminance standards to create emotionally resonant and perceptually adaptable environments. Optimising light colour and brightness can improve spatial usability and psychological well-being, supporting the broader aims of sustainable, human-centred architecture in hot-humid climates.

### 4.3 Thermal Perception Outcomes

Figure 8 indicates that the thermal perception data collected from participants demonstrates a nuanced understanding of thermal experience within the semi-conditioned tropical environment. Despite the ambient air temperature averaging  $28.2 \pm 0.7^\circ\text{C}$ —conditions usually considered warm—45% of respondents reported thermal comfort (TCV), while 55% expressed a sensation of coolness (TSV). Only 15% of participants reported warm or hot thermal sensations, pointing to a disconnect between objective temperature measurements and subjective comfort responses.



**Fig 8.** Thermal Perception Measurements.

In this study, participants were placed in a visually modulated environment, where high-CCT artificial lighting (mean CCT: 6140 K) and reflective interior finishes created a bright, engaging space. While thermal measurements alone might predict discomfort at  $28^\circ\text{C}$ , the cooler-toned lighting may have psychologically reduced the sensation of

warmth, leading to more neutral or even cool TSV reports. This supports the concept of perceptual cooling, a phenomenon validated in studies by Chinazzo et al. (2019) and Brambilla et al. (2020), where visual stimuli—particularly correlated colour temperature—interact with thermal experience, influencing reported comfort levels [22, 25].

Furthermore, the thermal comfort vote (TCV) distribution indicates that comfort judgments might involve adaptive or compensatory mechanisms. As demonstrated by Omidvar & Brambilla (2021), when visual conditions are perceived as favourable, they can influence physiological responses and lessen discomfort linked to heat [20]. This is especially relevant in tropical environments where indoor temperatures often exceed standard comfort levels. Consequently, positive visual cues, such as soothing lighting colours, pleasing visual atmosphere, and overall brightness, may help extend individuals' subjective tolerance to thermal conditions.

These findings also underline the importance of examining thermal comfort not only as a reaction to air temperature but as a multisensory experience that includes light, sound, and even tactile feedback. In naturally variable settings, such as the semi-conditioned library workspace observed in this study, cross-modal interactions are essential for understanding real-world comfort patterns.

While the correlation analyses between thermal perception and environmental variables were not statistically significant, the pattern of participant responses aligns with increasing evidence that psychological adaptation mechanisms—driven partly by visual perception—play a vital role in shaping thermal comfort in low-energy buildings [20, 22]. These insights highlight the need for a broader understanding of indoor comfort that includes subjective and perceptual aspects alongside measurable environmental data.

#### 4.4 Correlation Between Visual and Thermal Perception

The primary aim of this section was to assess the potential link between visual comfort indicators—such as brightness, colour comfort, warm-cool association, and overall visual acceptability—and subjective thermal outcomes, measured through Thermal Sensation Vote (TSV) and Thermal Comfort Vote (TCV). Pearson correlation analyses were performed to examine these relationships across a sample of 42 participants.

Table 3 and Figure 9 showed that all relationships with TSV were weak ( $R^2 < 0.01$ ) and statistically insignificant ( $p > 0.05$ ). This indicates that perceived visual conditions had minimal influence on how participants sensed temperature in terms of physiological heat or coldness. Conversely, relationships between visual variables and TCV—particularly Colour Comfort Vote (CCV)—were somewhat stronger, with CCV demonstrating the highest correlation to TCV ( $R = 0.208$ ,  $R^2 = 0.043$ ) (Figure 9). Although not statistically significant ( $p = 0.187$ ), this suggests a modest positive link between visual colour comfort and thermal comfort perception.

**Table 3.** Pearson Correlation Between Visual and Thermal Perception

Indicators		TSV	TCV
<b>LCV</b>	R	0.088	0.171
	R <sup>2</sup>	0.008	0.029
	Sig. (2-tailed)	0.579	0.280
	p-value	1.2.E-02	8.2.E-06
<b>CCV</b>	R	-0.008	0.208
	R <sup>2</sup>	0.000	0.043
	Sig. (2-tailed)	0.960	0.187
	p-value	2.8.E-03	1.9.E-05
<b>CWA</b>	R	0.082	0.161
	R <sup>2</sup>	0.007	0.026
	Sig. (2-tailed)	0.607	0.309
	p-value	2.6.E-04	1.6.E-09
<b>LPV</b>	R	0.013	0.193
	R <sup>2</sup>	0.268	0.037
	Sig. (2-tailed)	0.933	0.220
	p-value	8.9.E-09	3.7.E-05

These findings offer empirical support for the idea that thermal comfort, unlike thermal sensation, can be influenced by cognitive factors through visual cues. This interpretation is based on the distinction between sensation and comfort proposed by Wang et al. (2018), where thermal sensation is a direct physiological response, whereas thermal comfort is a subjective assessment shaped by context, expectations, and psychological adaptation.

The pattern of correlation aligns with earlier studies that investigate cross-modal sensory effects in built environments. Kulve et al. (2018) showed that visual stimuli such as colour and brightness can influence thermal comfort, particularly under borderline or transitional thermal conditions [20]. Likewise, Omidvar & Brambilla (2021) suggested that light colour temperature serves as a perceptual cue, affecting thermoregulatory responses through non-thermal pathways [20].

The slightly stronger link observed between CCV and TCV (compared to other visual signals) may be explained by the emotional aspect of colour. Chinazzo et al. (2021) argue that colour temperature can influence emotional perceptions of space—cooler shades being linked to freshness and spaciousness, while warmer shades suggest intimacy and warmth [18]. In a hot, humid climate, cooler visual tones might psychologically enhance comfort by creating sensations of coolness, even if physical conditions remain unchanged.

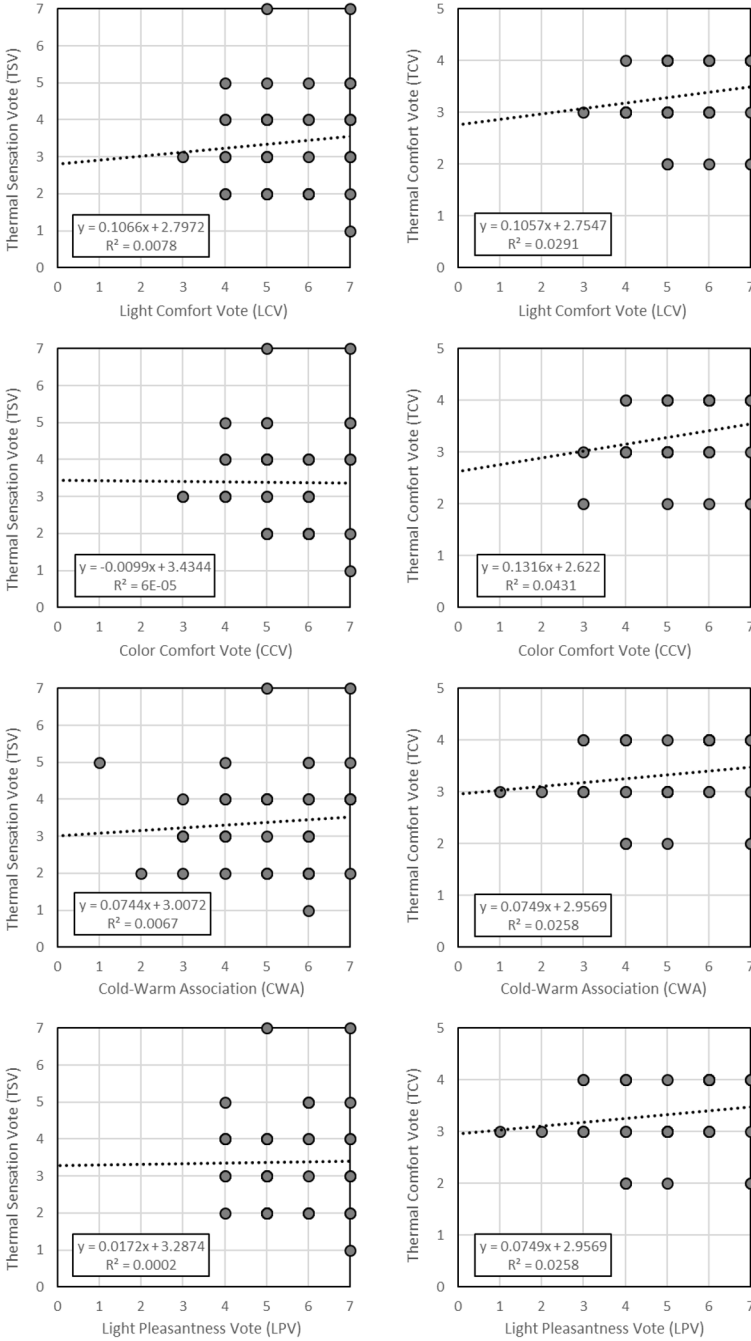


Fig 9. Regression Analysis of Visual Comfort and Thermal Comfort Indices.

Furthermore, the results show weak associations between lighting pleasantness (LPV), cold-warm association (CWA), and TCV highlight the complex interaction of multisensory inputs. Although individually modest, the combined impact of visual comfort characteristics could produce a more noticeable effect when viewed as part of an integrated indoor environmental quality (IEQ) framework. This aligns with the holistic design approach proposed by Sorkhan et al. (2024), which advocates for including multisensory environmental feedback in user-focused architectural strategies [5].

It is important to note that the absence of statistically significant correlations does not invalidate the conceptual validity of cross-modal effects; rather, it reflects the inherent complexity of studying perception in real-use settings. As Brambilla et al. (2020) emphasize, perceptual modulations in semi-conditioned or naturally ventilated environments are often subtle, yet impactful when accumulated over time or under varying environmental loads [23].

In summary, the findings of this study support a growing body of evidence that indicates that visual comfort, especially through colour, can slightly influence perceived thermal comfort. These findings are relevant to design, particularly in hot-humid climates, where visual strategies can serve as passive, perceptual methods to improve thermal satisfaction and possibly reduce energy loads associated with active cooling.

#### 4.5 Interpretation and Comparative Analysis

The results of this study highlight an important distinction between thermal sensation (TSV) and thermal comfort (TCV) regarding visual perception. Although quantitative data did not produce statistically significant correlations between visual and thermal variables, especially TSV, the qualitative patterns indicate perceptual mechanisms at play, particularly in the case of light colour comfort (CCV) and its modest connection with thermal comfort.

This observation supports the broader hypothesis of cross-modal perception, where sensory input from one domain (visual) influences another (thermal). As explained by Omidvar & Brambilla (2021), light, especially its colour temperature, can affect human thermal responses not through direct physical interaction but via psychological cues and cognitive associations [20]. In this study, participants who reported greater comfort with light colour (CCV) also tended to rate the thermal environment as more comfortable (TCV), even though the actual temperatures averaged around 28.2°C, a level generally regarded as warm in tropical climates.

This aligns with the findings of Brambilla et al. (2020), who demonstrated that cooler-toned lighting (i.e., high-CCT light sources) tends to evoke perceptual cooling effects [23]. Their study suggested that even without changes in physical air temperature, variations in light quality could shift user comfort levels by altering the cognitive framing of the thermal experience. Similarly, Chinazzo et al. (2019) observed that day-light exposure can influence thermal perception, reinforcing the importance of visual cues in shaping multisensory comfort [22].

The lack of correlation between TSV and any visual indicators further highlights the difference between physiological thermal sensation and cognitive-emotional thermal comfort. TSV, as a direct measure of perceived body temperature, is mainly controlled

by internal thermal regulation mechanisms, whereas TCV seems more responsive to environmental and perceptual influences. Wang et al. (2018) confirmed this by emphasising that emotional states and environmental aesthetics, including colour, can influence comfort evaluation more than sensation thresholds [24].

The semi-conditioned nature of the study site enhances ecological validity in these interpretations. Unlike fully controlled laboratory environments, the dynamic and variable conditions of the real-world library may have diminished stronger effects but more accurately mirror actual occupant experiences. As Kulve et al. (2018) argue, naturalistic settings are vital for revealing subtle perceptual interactions that affect comfort, particularly in climates like Surabaya, where buildings function without strict environmental controls.

When compared to similar studies in tropical environments, the findings presented here align with those of Faraj et al. (2023), who examined classroom comfort in Malaysia and found that students often relied on visual cues to interpret thermal conditions, particularly in naturally ventilated scenarios [16]. Likewise, Kwon (2020) noted that design factors, such as lighting aesthetics and colour scheme, contributed to thermal satisfaction levels in adaptive-use educational buildings [14].

Overall, this study confirms that thermal comfort is a multidimensional experience, influenced not only by physical environmental metrics but also by subjective visual impressions. Although the effect sizes may be small, their implications for low-energy design strategies are significant. Designers can utilise perceptual cues, such as very light colour temperatures and pleasant visual aspects, to subtly improve occupant thermal comfort without relying solely on mechanical systems.

## 5 Conclusion

This study examined the connection between visual perception, specifically light colour and brightness, and thermal comfort in a real-world collaborative student workspace at a tropical university. By combining physical environmental data with subjective responses, the study assessed whether visual comfort indicators could predict thermal perception outcomes.

The findings showed that while visual indicators, such as exceptionally light colour comfort (CCV), had a weak to moderate effect on thermal comfort votes (TCV), there was no significant link with thermal sensation votes (TSV). This suggests that thermal comfort may be partly influenced by psychological perceptions created by visual cues, but thermal sensation is mostly physiological.

Using natural variables, semi-conditioned indoor environments enhance the ecological validity of the study, distinguishing it from earlier research conducted in fully controlled lab settings. Consequently, this research contributes to a growing body of evidence emphasising the significance of visual context in adaptive thermal comfort strategies.

The study presents numerous design ideas, particularly for developing strategies that use less energy in tropical regions. The suggestions are as follows:

1. Altering the colour of the light may have little effect on how comfortable people feel in terms of temperature, especially in schools or other places where complete mechanical cooling is not possible or acceptable.
2. Designers should consider integrating cooler-toned artificial lighting (e.g., >5000K) in warm tropical indoor environments to promote perceptual cooling effects without increasing air conditioning loads.
3. Along with thermal and acoustic metrics, visual comfort factors like how pleasing the lighting is and how acceptable the colours are should be considered when measuring indoor environmental quality (IEQ).

Architects and engineers can utilise visual perception as a psychological tool for thermal adaptation, broadening the temperature range in which people can work comfortably and making indoor spaces more durable and people-focused.

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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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