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Perceived Benefits of Lighting Design Parameters on Performance and Emotional Wellbeing: A Case Study of Creative Workers in Vietnam

Huong Ly Duong[1, a)] and Chanyaporn Bstieler[1]

[1]*School of Architecture and Design, King Mongkut's University of Technology Thonburi, Soi Thian Thale 25, Bang Khun Thian Chai Thale Road, Tha Kham Bang Khun Thian, Bangkok 10150 Thailand.*

[a)]*Corresponding author: huongly.duo@mail.kmutt.ac.th*

Abstract. In today's world, the connection between how employees perform and their overall well-being has become crucial for the success of organizations. This study focuses on the factors that affect creativity and well-being specifically looking into lighting, which includes both natural light and artificial colored lighting. While studies from previous researchers have extensively examined office lighting, including colored light in controlled laboratory settings. This limitation makes it difficult to draw findings when applying them to workplace environments. To address this gap in research, the researcher conducted a qualitative case study within workplaces in Vietnam involving creative employees and their daily tasks. Data acquisition will transpire through surveys, direct on-site assessments, and semi-structured interviews, employing open-ended queries, which revealed some findings. Even though a survey conducted by this study has found that natural light is known to have benefits, artificial lighting remains the primary source of illumination in modern workplaces due to concerns about glare, heat and UV ray protection. Employees consistently showed a preference for scenes that incorporated elements of nature like views or indoor greenery. This highlights the appeal of incorporating design into office spaces. The use of colored lighting is generally not maximized, during work periods. However, when employees are given the opportunity to use break-out rooms for periods, there is a clear increase in the use of colored lighting. Based on the participants' perception, it suggests that colored lighting has the potential to improve well-being and stimulate creativity in situations. By studying these patterns in office environments this research provides insights into how we can effectively incorporate colored lighting to enhance employee emotional well-being and creativity.

Keywords: colored lighting, office lighting, daylighting, views, emotional well-being, creative work

INTRODUCTION

According to a report, there has been an expansion in the range of creative industries considered part of the field in recent years (National Endowment of the Arts, 2019).The reason behind this growth can be traced back to the dynamics among businesses, where innovation plays a role in achieving success. Building on research on creativity Zhang and their colleagues introduced a concept called "creative performance." This concept captures individuals' inherent capacity to come up with ideas in their pursuits (J. Zhang et al., 2017). Beyond performance another important aspect is the well-being of individuals, which has gained significant attention when it comes to modern office designs. In enhancing both performance and overall well-being, various environmental factors play a role within this multifaceted domain. According to IES (Illuminating Engineering Society) standards (Illuminating Engineering Society. ANSI/IES RP-1-20, 2020), the recommended light level for office work typically falls within the range of 500 to 1000 lux, depending on the type of task and age. In Vietnam, in accordance with the National standards (Ministry of Science and Technology, 2008), the recommended light level for office work is set at 500 lux. Regarding color temperature, based on the investigator's observations, the prevailing practice in Vietnamese offices typically falls within the range of 4000K to 5000K. Besides, elements such as daylight, views, user-adjustable lighting (and particularly colored lighting) are lighting design characteristics that have been linked to positive outcomes or suggested as desirable features, influencing better performance, moods, and satisfaction. However, most previous studies conducted in a control environment and none directly addressed creative workers. Therefore, research efforts focused on understanding these issues are highly valuable and should be thoroughly investigated.

LITERATURE REVIEW

Effect of daylighting and views on performance and well-being

The psychological facets of well-being are gaining increasing recognition and are being investigated as fundamental elements of overall human health, particularly within the corporate workforce. In a study conducted in 2023, Park et al. (Park et al., 2023)introduced a concept of emotional well-being, which is a comprehensive construct that encompasses an individual's general sense of positivity, both in their day-to-day experiences and their overarching outlook on life. It comprises experiential components, such as moods and daily encounters, as well as reflective aspects, which encompass evaluations of life satisfaction, perceptions of meaning, and the capacity to pursue goals, which can encompass a scope extending beyond the self. A recent international study involving office workers from 16 countries revealed a finding (Pérez Vega et al., 2022). Natural light and views of nature ranked among the top five desired characteristics in a workplace. When it comes to the workplace the quality of lighting emerges as a concern. It becomes evident that proper workplace lighting can have an impact, on employee's mental health. Such lighting interventions have been observed to improve mood reduce eye strain, combat fatigue and significantly boost morale (Deng et al., 2021). Supporting these findings an earlier study emphasized that employees working in environments with daylight and full spectrum lighting reported higher levels of well-being and job satisfaction (Rea, 2015). These positive outcomes translated into benefits such as reduced absenteeism, increased productivity, improved health, better sleep quality and a notable decrease, in workplace accidents. It becomes clear that making decisions regarding lighting can lead to impacts, on the emotional well-being of workers.

Effect of colored lighting on mood and creative performance

Colored LED lighting has garnered substantial attention in lighting and psychology research (Plitnick et al., 2010; Varkevisser et al., 2011, Elliot et al., 2007). Nevertheless, the conclusions drawn from these studies remain inconclusive. While a majority of investigations posit that colored lighting yields a positive impact on individuals' emotional states, a subset has documented adverse effects. For example, some studies discovered that red and blue lighting could elicit positive emotions (Plitnick et al., 2010; Varkevisser et al., 2011). Conversely, Kim and Mansfield identified a heightened sense of liveliness in environments featuring task lighting with saturated blue and cyan accent hues (Kim & Mansfield, 2021). In contrast, Wilms' study revealed a significant increase in participants' heart rates when exposed to colored light, signifying a negative influence (Wilms & Oberfeld, 2018). In terms of creative performance, numerous studies have investigated the association between color and creativity contributing to this field. Some studies suggest that red enhances task performance more than blue (Elliot & Aarts, 2011; T. Zhang & Han, 2014), while others have yielded opposite findings (Elliot et al., 2007) or found no significant differences in performance among employees working in offices with colored walls (Küller et al., 2009, Bakker et al., 2013). Another findings suggest that compared to white accent light, blue and red accent lighting elicits stronger approach behavior and improves performance in creativity tasks (Kombeiz & Steidle, 2018).

Limitations and gaps in existing research

In a publication by Bakker (Bakker et al., 2014), the authors explore several factors that may explain the conflicting results found in existing studies on the influence of color on human behavior and cognition. One major factor identified is the limitation of laboratory settings in reflecting the complex physical and social contexts of real-life situations, which can influence color perception and behavior. Another factor to consider is the participant selection bias in most color studies. Given that students may not be representative of the overall population, their motivations and experiences may differ from those of real-life employees. The task and its assessment also pose a challenge when comparing artificial tasks to real-life task. Moreover, the use of different colored test materials in laboratory environments, such as virtual screens (Mehta & Zhu, 2009; Xia et al., 2016) or color photographs (Xie et al., 2022), may lead to varying research findings due to the materials' different characteristics. Finally, focusing on different topics, such as creative performance and approach motivation (Kombeiz & Steidle, 2018), or mood, arousal, pleasure(Elliot et al., 2007; Kim & Mansfield, 2021), further complicates comparisons of research findings.

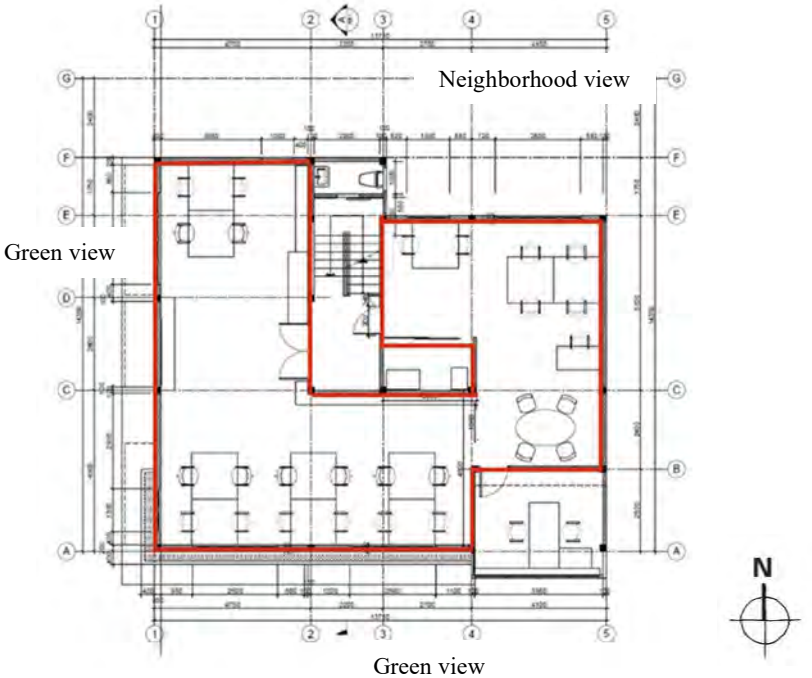
METHODOLOGY

To investigate how the perceived effects of lighting, including factors like visual comfort and clarity, influences creative performance and emotional well-being, such as fostering moods and overall satisfaction, this study employs a qualitative research methodology, utilizing a case study design within authentic workplace settings involving real employees and their respective tasks. Evidence will be gathered through questionnaires, direct observations, and semi-structured interviews with open-ended questions. The goal is to examine what are the strategies for implementing lighting, especially colored lighting in creative industries to enhance performance and well-being effectively.

STUDY DESIGN AND PROCEDURE

Setting

In this research, we focus on a lighting studio situated in a two-story villa in district 1, Ho Chi Minh City, Vietnam. The study zeroes in on the first-floor workspace of the design team, encompassing six clusters of desks assigned to designers (refer to Figure 1). Each workstation boasts a customized lighting system, including indirect LED strips on the ceiling, two decorative pendant lights, and four adjustable task lights with a 3000K color temperature. These lights employ an RGBW color system, offering employees at each desk cluster full control over brightness and color. This office was chosen for several reasons: (1) It has utilized colored lighting for over two years. This extended exposure aligns with research indicating a minimum of two months for participants to adapt to colored lighting (Bakker et al., 2014). (2) Given creativity's critical role in all industries, studying creative performance in such an environment is pertinent. (3) The research takes place in a genuine workplace with real tasks and employees, eliminating potential biases from controlled experiments with students and artificial tasks.



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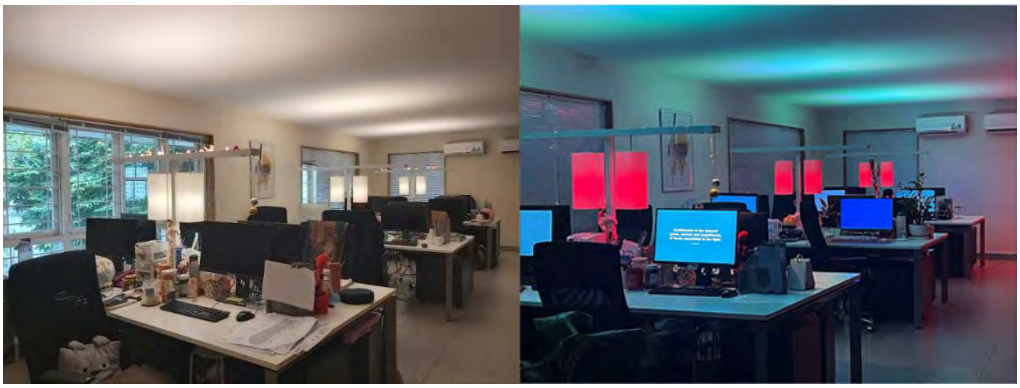
a)



b)

FIGURE 1. a) Floor plan of the study area (highlighted in red) and b) photograph of the lighting system (white light and colored light) at each workstation.

The study encompassed a total of 23 participants, with 20 full-time lighting designers and 3 part-time interns. The gender distribution was as follows: 14 female participants and 9 male participants. Regarding age, the study participants fell within a relatively narrow range, spanning from 22 to 34 years old. The office's regular working hours are from 9:00 AM to 5:30 PM. However, in cases of impending deadlines, employees have the option to extend their working hours until 8:00 PM. Moreover, overtime work is relatively frequent, with most employees working extra hours for about 4 to 5 days per month. The onsite lighting parameters were also measured using the Sekonic Spectrometer C-800 in three distinct scenarios, under daylight conditions on typical working days, average at 11.00AM: when all blinds were closed, signifying the utilization of 100% artificial lighting; when blinds were halfway closed, and when blinds were fully open. The results of these measurements are presented in Table 1 below.

TABLE 1 The on-site measurements for average illuminance and color temperatures

	Closed	**Halfway closed**	**Fully open**
Average illuminance (lux)	350-400	400-450	550-600lx
Color temperature (K)	3000	3500	3800

The procedure was divided into two phases. In the first phase, participants were administered a survey designed to assess various dimensions related to their work environment, daylighting, and colored lighting. To ensure data triangulation, a direct observation approach was also employed. In this context, the researcher assumed the role of a designer and documented the employees' behaviors for a duration of one month. Building upon the findings from the first phase, an experimental phase was subsequently conducted. A breakout room was set up within the office space, and each employee underwent a 30-minute experience within this room. During this interval, participants were tasked with performing various assignments and were given the opportunity to experiment with different colors and levels of dimming in the lighting. Following the 30-minute period, participants were required to complete a questionnaire pertaining to their perceptions of the most suitable lighting setting corresponding to each specific task.

RESULTS

Phase 1 – Questionnaires

Within the context of daylighting, the influence of natural light is predominantly perceived in a favorable light. Approximately 50% of respondents asserted its positive impact on their work performance, while a smaller portion (27%) regarded it as having a negative influence. A minority held the view that natural light had no discernible impact or acknowledged both positive and negative effects. In terms of its impact on mood, a majority (65%) attested to its positive influence on their mood, with a mere 8% perceiving any negative implications. In terms of the view aspect, 83% of the respondents preferred a view with greenery. This result is remarkable when compared to other responses like the sky, colleagues, or artwork.

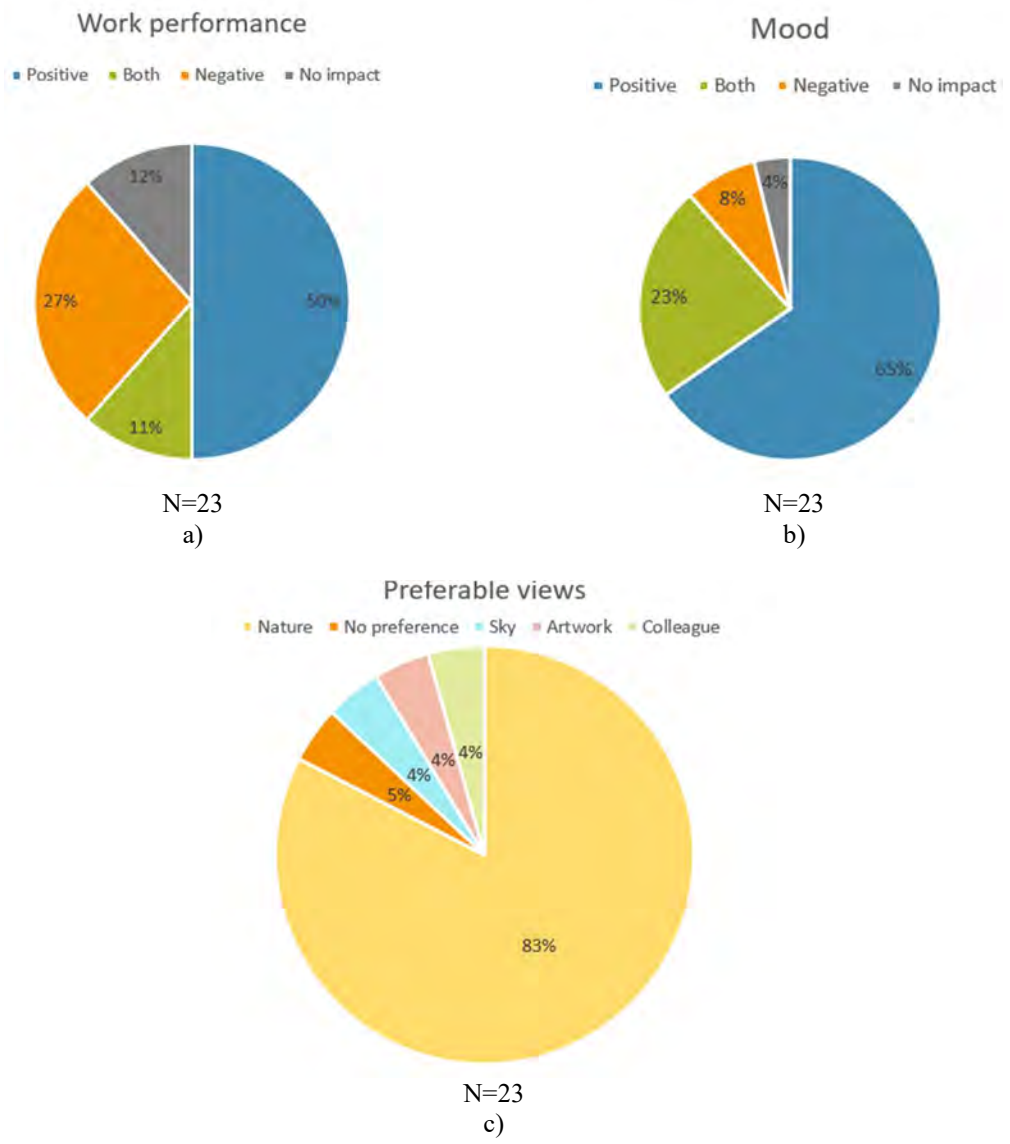


FIGURE 2. Results on employees' perceptions of the influence of daylighting on a) work performance, b) mood and c) preferable views.

However, despite these generally positive evaluations, it is notable that the majority of employees continue to employ blinds within the office space. The primary reasons for this, in descending order of frequency, include visual and thermal comfort, and safeguarding their skin, particularly female. These results suggested that while natural light is appreciated for its positive contributions to performance and mood, practical considerations necessitate the utilization of blinds. Furthermore, based on the on-site measurements (Table 1), it appears that the majority of employees are generally satisfied with the artificial lighting conditions when all blinds are closed, which registers at approximately 350-400 lux, depending on visual tasks. Notably, this observed light level falls below the recommended standards set by both the IES and the National standards in Vietnam, which prescribe 500 lux. Moreover, the study delved into the utilization of colored lighting within the office environment. Despite prior research highlighting the potential of colored lighting to enhance work performance, the survey results indicated that nearly 87% of employees still opt for white lighting during work. The usage of colored lighting is infrequent, with 48% of respondents using it primarily during evening hours after work or reserving it for special occasions. Concerning the impact of colored lighting on performance, the majority of employees (61%) perceived either negative effects or no effect at all (26%). In contrast, the influence of colored lighting on mood painted a different picture. A significant 48% of employees reported a positive effect on their mood, whereas 26% believed that colored lighting had an adverse impact on their emotional state.

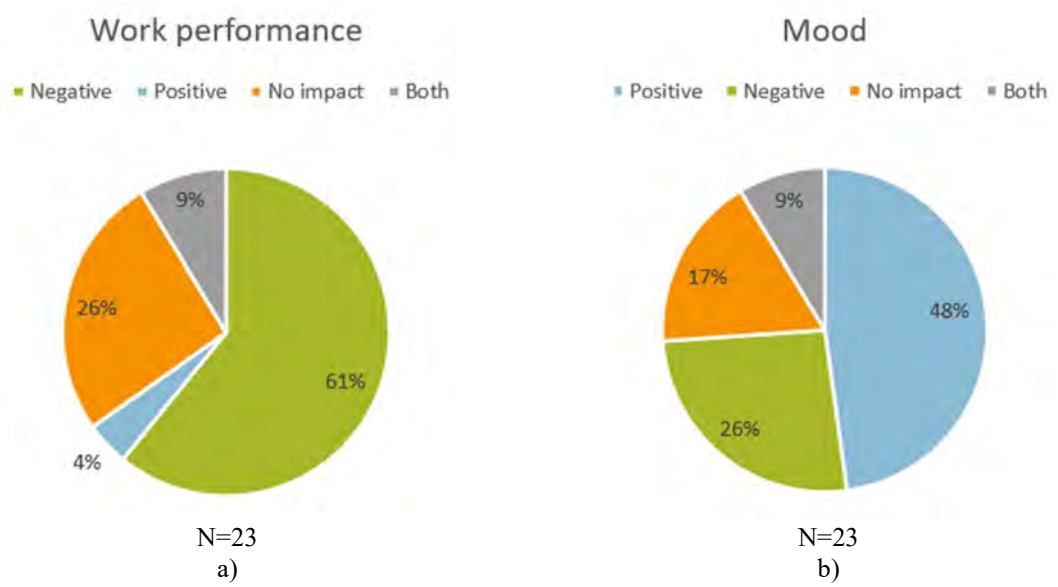


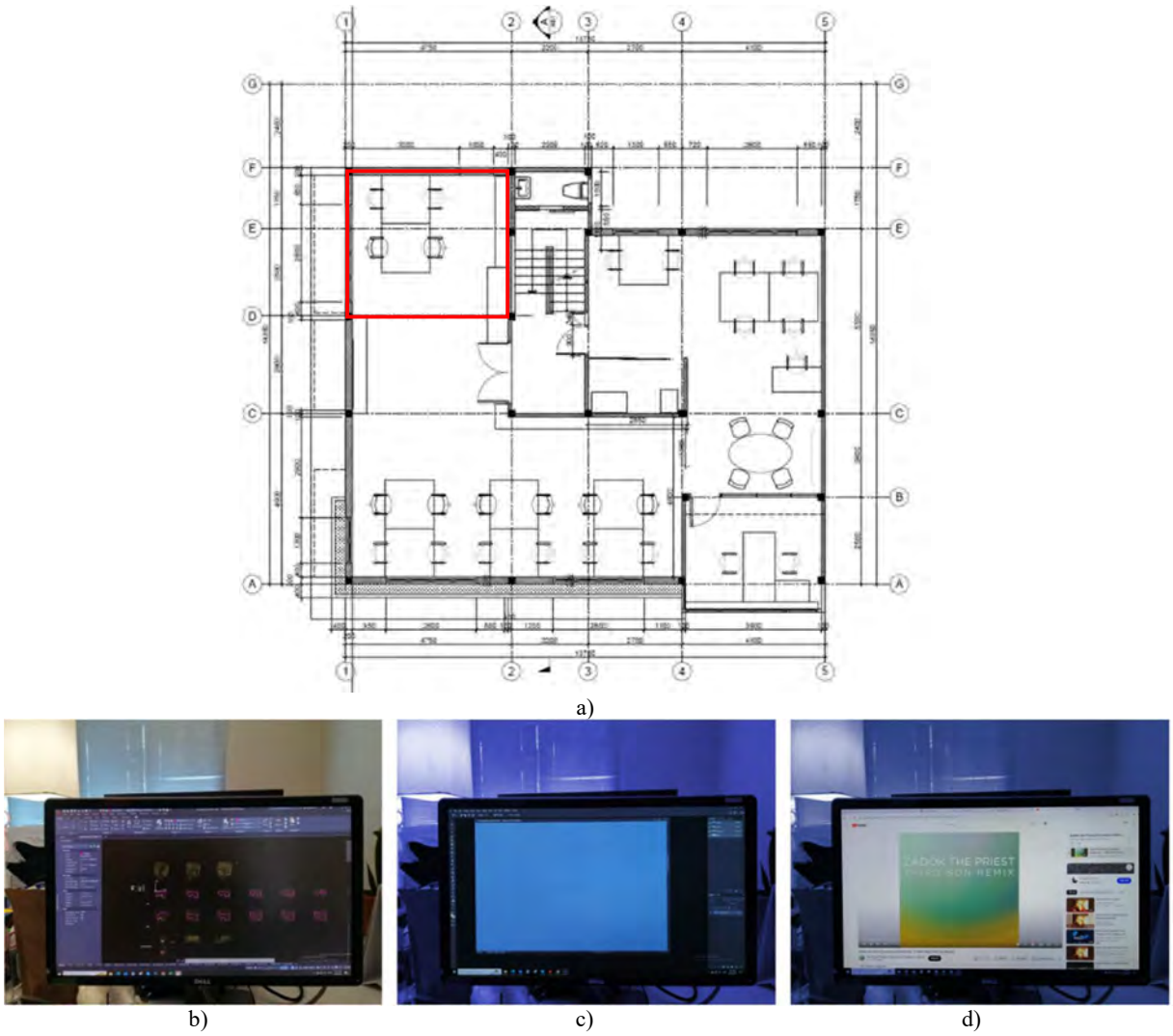
FIGURE 3. Results on employees' perceptions of the influence of colored lighting on a) work performance and b) mood.

Phase 1 - Direct observation

Over the span of a month, employees within the office complex exhibited selective use of colored lighting on only two distinct occasions: firstly, during visits by external guests, and secondly, on days characterized by heavy rainfall. Conversely, on the vast majority of days, which includes both normal condition days and rainy ones, the color temperature remained unwavering at 3000K. It is worth noting an exception during this timeframe, wherein a specific team of employees chose to deviate from this norm on a different rainy day, adjusting the color temperature to a warmer 2700K. Remarkably, this adjustment was sustained for a continuous period of two days. These observations are consistent with the findings from the employees' survey regarding the utilization of colored lighting and daylighting.

Phase 2 – Experiment

Based on the outcomes of the initial survey, it is evident that the majority of employees primarily resort to colored lighting when hosting guests or during special occasions. This tendency may, in part, be attributed to the office's open-plan layout. Consequently, an experiment was conducted to delve deeper into this aspect. A compact space, designed as a breakout room within the office premises, was set up for this purpose. Each employee was allocated a 30-minute session within this breakout room. During this timeframe, participants sequentially experienced different color temperatures, lighting hues, and dimming levels while engaging in tasks and relaxation activities. Given that the majority of employees predominantly work on computers, detailed-oriented tasks involved working with AutoCAD, creative tasks encompassed activities in software like Photoshop, or PowerPoint. The choice of relaxation activity varied based on individual preferences. Following these experiences, participants were tasked with completing a questionnaire aimed at soliciting their perceptions regarding the most suitable color temperature, lighting hues, and dimming levels corresponding to each specific task. Subsequently, a series of interviews featuring open-ended questions will be conducted with select participants to gain insight into their choices. The researcher selected a corner within the office (figure 4) and temporarily used a partition to create a breakout room. The experiment was conducted at 6:00 PM, after working hours, aligning with the evening timeframe to ensure that it is not interfered with by daylighting or lighting from other areas within the workspace. Furthermore, this time frame was chosen due to the lower number of employees present, facilitating increased focus for the participants on their tasks. The entire lighting system remained unchanged. Participants were provided with a smartphone application called Aurora Smart BLE to control the entire lighting system. They were granted the autonomy to select their preferred lighting settings, akin to those used during typical working hours. Notably, the key distinction lay in the reduced presence of other individuals, creating an atmosphere akin to a private breakout area.



a) b) c) d)

FIGURE 4. a) Location of the break-out room on the floor plan (highlighted in red) and the views of employees at their desks for three tasks, from left to right: b) detailed-oriented task, c) creative task, and d) relaxation.

Phase 2 - Experiment results

According to the results of the survey conducted afterward, following their experience of working and relaxing in the breakout room, 87% of those surveyed indicated that they would choose to use the breakout room for relaxation rather than work. This is a highly significant figure. Regarding the question of the type of color temperature or colored lighting they used for detailed-oriented tasks, specifically AutoCAD, the survey revealed that 61%—more than half—opted for a color temperature of 4000K, 39% chose 2700K, and no one selected colored lighting. For creative tasks, the survey recorded intriguing results with the presence of various colors and color temperatures. Leading the choices was blue at 39%, followed by 4000K at 35%, then 2700K at 22%, and 4%—equivalent to one participant—chose pink. Regarding the selection of colors and color temperatures for relaxation, 48% of the participants chose 2700K, 44% selected blue, and 4%—two participants, each—chose purple and pink. Not a single participant chose 4000K. Regarding the dimming level, for tasks involving the use of AutoCAD, participants who opted for a color temperature of 2700K tended to keep the lighting at a dimming level ranging from 50% to 70%. Conversely, for those who chose a color temperature of 4000K, there was a wider range of dimming levels, spanning from 50% to 100%. For creative tasks, across all colors and color temperatures, dimming levels ranged from 70% to 100%. There was minimal variation in dimming levels among different colors because all participants maintained high-intensity lighting. When it came to relaxation, there was a noticeable distinction between white and colored lighting. For 2700K, the dimming level remained relatively low, ranging from 10% to 20%. In contrast, for colored lighting, dimming levels were consistently within the range of 50% to 80%.

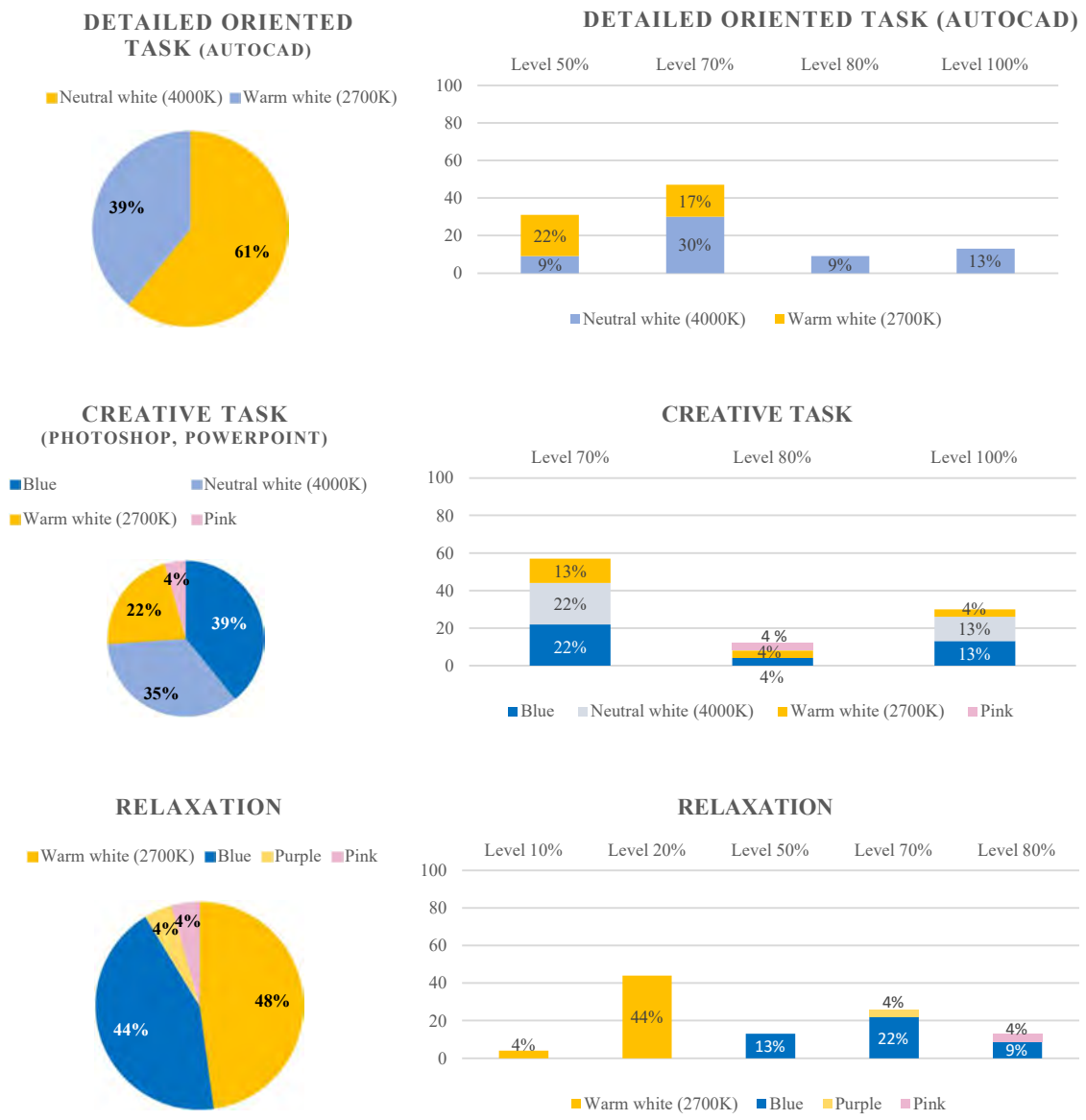


FIGURE 5. Results on preferred colors, color temperatures, and the relationship between color temperature and dimming level for detailed-oriented tasks, creative tasks and relaxation.

From these results, two conclusions can be drawn: First, for work-related tasks, whether they were detailed-oriented or creative in nature, participants tended to maintain brightness levels above the average. Dimming levels were only adjusted to below-average levels during relaxation. Second, specifically concerning colored lighting, whether for work or relaxation, participants consistently kept the brightness at above-average levels.

Interviews

Following the survey, interviews were conducted with selected participants to gain insights into their choices. Participant 5, who exclusively used white lighting for all tasks, reported that colored lighting caused headaches and distraction, while high dimming levels helped him stay alert, and low levels facilitated relaxation and sleepiness. Participants 6 and 7 shared similar views regarding the impact of white lighting (participant 6,7). Regarding choices for creative tasks and relaxation, participant 8, for example, explained that they chose pink for creative tasks because their home office was predominantly pink, making them feel comfortable and at home, thus enhancing their creative inspiration. Blue, on the other hand, was associated with a pleasant and relaxing feeling, as per their account. However, they also noted that pink was suitable only for short durations. Another participant chose pink for relaxation, as they used relaxation time for gaming and listening to music, and pink was associated with happiness for them. Someone else opted for purple for relaxation and blue for creative tasks. Blue induced a

sense of comfort and inspiration, while purple, being a darker shade, helped induce sleepiness compared to blue. The majority of participants interviewed agreed that colored lighting was suitable for expressing personal preferences (participant 8,12,16), fostering inspiration (participants 10 and 14), and relaxation (Participants 13,16, and 18) for short periods, typically under 30 minutes, rather than for extended work periods.

CONCLUSIONS

Based on the results obtained from the survey, direct observation, experiments and interviews, several key conclusions can be delineated as follows: (1) While daylight and views are considered positive, practical concerns such as issues related to visual and thermal comfort, as well as the preference for light skin among Asian females that necessitates skin protection, have led the majority of employees to persistently employ window blinds throughout their working hours. Consequently, artificial lighting remains the primary source of illumination within office. (2) Among the various visual landscape from the workplace window, a preference is consistently expressed for scenes infused with elements of nature. (3) In the realm of colored lighting, contrary to the controlled environments, real-world observations reveal that employees seldom engage with colored lighting during work periods in an open and shared workspace. (4) In situations where employees have a chance to briefly use a private space, they tend to use colored lighting more often. It's important to note that they mainly use it for creative tasks and relaxation than tasks that require careful attention. (5) When it comes to white lighting, intense illumination is considered suitable, for tasks that demand focus. Conversely, low-intensity illumination is deemed suitable for fostering relaxation. In the context of colored lighting, regardless of the nature of the task—be it creative or relaxation-oriented—the dimming level consistently hovers above the mean illumination intensity. These empirical findings collectively contribute to a more comprehensive understanding of office design's intricate interplay with employee productivity and well-being. They further underscore the disparities between outcomes derived from real-world office environments and those stemming from controlled laboratory conditions.

LIMITATION AND FUTURE RESEARCH

This study also possesses certain limitations that warrant consideration for future research endeavors. Firstly, given that this investigation was conducted within a lighting design office, the participants have a higher level of understanding about lighting compared to individuals in other design or creative firms. Consequently, it remains conceivable that employees in alternative design domains or those operating outside the purview of creative industries may offer distinct perspectives. Hence, forthcoming research initiatives should prioritize the examination of these divergent cohorts. Secondly, it is imperative to acknowledge that the sample size employed in this study comprised a modest cohort of 23 participants. In light of this limitation, it is advisable to encompass a larger and more expansive sample. This adjustment would facilitate a more comprehensive scrutiny of the obtained results, thereby enhancing the robustness and generalizability of the findings. Furthermore, it is essential to recognize that this research was conducted within an authentic office environment, thereby introducing additional layers of complexity associated with various contextual factors. These contextual elements, which encompass considerations such as gender, job role characteristics, and other potentially influential variables, may introduce nuances into the study's outcomes. Thus, future investigations should be attuned to these factors, striving to conduct more comprehensive and encompassing research to yield a holistic understanding of the subject matter at hand. Finally, to minimize the potential influence of daylight and lighting from neighboring workstations, the experiments were conducted after 6:00 PM, therefore the outcomes obtained under these circumstances may not fully capture the performance and emotional well-being during conventional working hours. In future research endeavors, it is advisable to conduct break-out room experiments during regular working hours and over an extended duration to yield more precise and comprehensive results.

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