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THE IMPORTANCE OF VISUAL COMFORT IN MALAYSIAN SHOP OFFICE BY ARTIFICIAL LIGHTING

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Abstract:

Workspace is a place should be concerned by society since that people spend one third of their life in it. The quality of workplace can be based on visual comfort and occupants' job satisfaction. Job satisfaction can affect not only occupants' performance during work and affects occupants physically and psychologically. Visual comfort is one of the factors can affect job satisfaction of office occupants. Poor visual comfort can cause eyestrain, eye fatigue and even affects occupants' circadian rhythms. This can affect occupants' moods and well-being. Visual comfort can be achieved by natural lighting and artificial lighting. This paper will just mention about artificial lighting. Artificial lighting plays a key role in creating a healthy environment that enhance visual comfort in office and increase productivity of office occupants since that natural lighting is not under control due to weather. This study aims to provide a better quality of working environment in shop office by applying appropriate artificial lighting and the effects on employees' performance during work. Objective of this study is to identify the factors that affect employees' performance based on visual sector. Investigate the job satisfaction of employees with their working environment and find out the effects of different level of illuminance and correlated colour temperature (CCT).

Keywords:

Artificial Lighting, Visual Comfort, Job Satisfaction, Office Environment

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Introduction

Today's workplace is no longer just a passive fixed activity space, but a space that might consists more flexible environmental activity. Office in Malaysia is not just limited to office building, it can be located at apartment and shop office. The increasing number of office space has led to the increase of office workers. Productivity of occupants can also be improved by providing the best physical working environment. The natural comfort of the workplace is considered vital because it promotes healthier, more productive employees and lower absenteeism rates among occupants. Visual comfort is one of the factors that can affects job satisfaction of office occupants. In order to achieve visual comfort, lighting plays an important role. Light influences the daily rhythm and well-being of humans in a physiological, psychological and biological way (Aries, 2005). Lighting can affect human perception, the human biological clock system tells the human body when to regulate multiple body functions such as body temperature, sleep patterns, cognitive performance, mood, well-being and the release and production of hormones. There are two types of lighting which is natural lighting and artificial lighting. Artificial lighting has significant effects on office occupants since natural lighting might cause glare to the occupant by using computer to complete their task. This study is to find out the factor of visual comfort by artificial lighting to improve job satisfaction of occupants.

Literature Review

Factor of Visual Comfort

Visual comfort is a subjective reaction to the quantity and quality of light within any given space at a given time. The concept of visual comfort depends on our ability to control the light levels around us. Both too little and too much light can cause visual discomfort. Just as importantly, changes in light levels or sharp contrast can cause stress and fatigue, as the human eye is permanently adapting to light levels. Visual comfort encompasses a variety of aspects, such as aesthetic quality, lighting ambiance and view. There are four factors that affect visual comfort of human:

- Views to nature
- Light quality
- Luminance
- Absence of glare
- ***Physical Effects***

Environmental conditions such as lighting are influencing factors on sleep quality and visual tiredness (Azmoon et al., 2013). Therefore, computer vision syndrome will occur to the office occupants. The computer use in office has increased significantly in the past 20 years. Computers are now as commonplace as telephones in workplaces. Currently, more than 175 million Americans use computers regularly in the workplace, and the growth of the Internet has ingrained computer use as a way of life. Symptoms of physical problems are increasing among computer users. The eye care community has also seen an increase in the number of clients requesting eye examinations due to symptoms they experience at the computer. This

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has led to the American Optometric Association (AOA) diagnosis of computer vision syndrome. According to the AOA, computer vision syndrome consists of the eye and vision problems associated with near work experienced during or related to computer use. The symptoms that most often accompany this condition are eyestrain, headache, blurred distance or near vision, dry or red eyes, neck ache or backache, double vision, and light sensitivity. The factors that most often contribute to computer vision syndrome are a combination of improper workplace conditions, poor work habits, and existing refractive errors. Lighting, vision, and posture are interrelated concepts. Workers are visually directed and will alter their posture to alleviate stress on the eyes. Therefore, alterations in body posture may be indicative of a visually stressful situation. Some of the symptoms of computer vision syndrome actually involve the head, neck, and shoulders (Anshel, 2007).

An important factor that affects workers' ability to see well in the workplace is the quality of light. Quality lighting, created by attention to brightness, contrast, quantity, and colour of light, results in visibility and visual comfort. Contrast between a task object and its immediate background must be sufficient to enable the worker to clearly view the task. Contrast ratios should be established to maximize productivity without increasing eyestrain. In general, a 1:3:10 ratio is ideal; that is, the task area should be less than 3 times as bright as its immediate surroundings (within 25° of the visual target) and 10 times brighter than the peripheral area (past 25°) (Illuminating Engineering Society of North America [IESNA], 1988). Too much or too little light can inhibit the worker's ability to effectively see the task. Comfortable light levels will vary by individual. For example, a 60-year-old worker needs 2 to 3 times as much light as a 20-yearold worker to achieve the same visual performance (K. Toomey, Director of Communications, Lighting Research Centre, personal communication, July 14, 2000). Comfortable light levels will also vary by task. The more rapid, repetitive, and lengthy the task, the more important it is to have enough light. With these types of tasks, the eye is more vulnerable to fatigue and the worker to declining productivity.

The visual symptoms that computer workers experience is the most obvious expression of the shortcomings in workplace ergonomics and worker visual characteristics. Because of the high visual demands of computer tasks and the visual shortcomings of many operators, vision problems and symptoms are frequent among computer workers. Most studies indicate that visual symptoms occur in 75% to 90% of computer workers (Dain, McCarthy, & Chan-Ling, 1988; Smith, Cohen, & Stammerjohn, 1981). By comparison, a study released by the National Institute for Occupational Safety and Health showed that only 22% of computer workers have musculoskeletal disorders. A large survey of optometrists (Sheedy & Parsons, 1990) indicated that 10 million primary care eye examinations are conducted annually in the United States primarily because of visual problems related to computer use. The most frequent problems reported in that survey were:

- Eyestrain
- Headache
- Blurred vision
- Dry or irritated eyes

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- Neck ache or backache
- Photophobia (light sensitivity)
- Double vision
- After-images

Psychological Effects

Assessing a visual environment requires the analysis of three main factors – the sources of light (artificial/natural), the distribution of light within the space (colour, intensity) and its perception. Light has a direct effect on the regulation of various biological functions, such as sleep, mood, and alertness. The sun (or an electric light bulb, if the light source is artificial) emits propagating energy, of which a limited range of wavelengths, included between infrared to ultraviolet, is perceptible to the human eye as light. Lighting directly influences our health and well-being, as well as human perception and experience of the surrounding environment. Lighting conditions in workplaces contribute to a variety of factors related to work satisfaction, productivity and well-being (Borisuit et al., 2015).

Many investigators have examined the effects of lighting quality in an indoor space and its effects on the work performance, comfort, and satisfaction of occupants (e.g., Chung & Burnett, 2000; Veitch, 2001b; Veitch & Newsham, 1998). Light controls the human biological clock and is, therefore, an important regulator of the human physiology and performance. Regular patterns of light and dark exposure each day are necessary to regulate circadian rhythms, including sleep-wake cycles (CIE, 2004; Veitch, 2001a). The coordination of these cycles contributes to sleep quality. Sleep has powerful restorative effects on the body and poor sleep quality has adverse effects on physical and mental health (e.g., Haack & Mullington, 2005; Kuppermann et al., 1995; Meerlo, Sgoifo, & Suchecki, 2008). Individual differences also influence sleep quality. Increased need for sleep is one of the symptoms of seasonal affective disorder, along with depressed mood, carbohydrate craving, and lethargy (CIE, 2004; Veitch, 2001a). Murray et al. (2006) suggested that a depressed person could have a more negative impression of his/ her surroundings, because of dysregulation between internal (circadian or annual) rhythms. The performance of office occupants will be affected during work and make wrong judgement on making decision.

Windowless Working Environment

In a windowless working environment, other than the natural view, natural lighting also plays an important role. Studies done by International Association of Lighting Designers (IALD) showed that quality of light can affect humans in many ways. For example, the productivity and satisfaction levels of the office workers can be positively influenced by well-designed illumination. When natural light biologically impacts workers, it can improve or disrupt their sleep, cognition, and overall wellbeing. It can also improve mood and stabilize employees' circadian rhythms, helping them to get a better and deeper night's sleep. Psychologically, natural light can decrease depression scores and even increase cognitive performance such as reaction time and activation (Kaplan & Rachel, 1993).

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There are few reports that highlighted the importance of lighting and other natural elements that can enhance productivity, health, and well-being in the workplace (World Green Building Council, 2016). A research by Northwestern University and the University of Illinois at Urbana-Champaign found that compared to the counterparts who work in windowless offices, office workers who are exposed to natural light sleep better, feel happier, are healthier and they are more likely to be active throughout the day. Workers having better rest will improve their work productivity. Some of the findings indicated that positioning workers near windows is an "overlooked opportunity to improve health and fitness," said Phyllis Zee, senior author of the report, a neurologist, sleep specialist and professor of neurology (Workzone, 2014). According to Northwestern (2014), "Workers are a group at risk because they are typically indoors often without accessing to natural or even artificial bright light for the entire day. The study results confirmed that light during the natural daylight hours has powerful effects on health". Wherever possible, the employees' working space should be nearest to the windows.

The benefits of natural light cannot be denied. "For most of us, at least the tiniest bit of a window and some natural sunlight would be a bonus, but most importantly, lighting should not cause headaches and eye strain," (Rice, 2010). However, when it comes to natural lighting in Malaysian offices, it brings too much glare in the office. Employees might not see the computer screen properly due to the reflection of lighting. At noon, the temperature of the office will increase because of the strong sunlight, which explains why people always want to put down the curtain even when they have window, preventing employees from getting the benefits of natural sunlight.

Correlated Colour Temperature (CCT)

Good lighting is required for good visibility of the environment and should provide a luminous environment that is human-friendly and appropriate for the visual task performed. Various studies have been conducted in order to identify the effects of lighting towards human health, productivity, and well-being and alertness level(Boyce et al., 2003; Hameed & Amjad, 2009; van Bommel & van den Beld, 2004).In regards of human perception, two of the most important characteristics of lights are illumination and correlated colour temperature (CCT)(Barkmann et al., 2012; Veitch & Newsham, 1998a).Recently, studies have proven that different CCT provided by different lighting are important in affecting human beings psychologically and physiologically, through their visual and non-visual processes(IEA, 2010). CCT is found to have effects on visual and mental fatigue. The right selection of CCT in an office environment will benefit its occupants in terms of visual comfort and reduction of daytime sleepiness. This will lead to an increase in productivity and prevention of health effects associated with inappropriate light CCT, such as eyestrain or the effects towards emotion and human circadian rhythm(Gornicka, 2008).

Correlated colour temperatures (CCT) of light play an important role in human psychological and physiological needs. Correlated colour temperatures (CCT) can have effects on worker's performances, alertness, visual comfort, and preferences. Previous study (Sivaji et al., 2013) showed significant increases of alertness levels when using WW lighting. CW and DL lights were more beneficial in office setting for computer-based tasks.

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Recently, studies had proven that different CCT provided by different lighting are important in affecting human psychologically and physiologically, as well as visual and non-visual processes (Sivaji et al., 2013). The right selections of CCT in an office environment will benefits occupants in term of visual comfort and reduction of daytime sleepiness. This will increase of productivity and prevention of health effects associated with inappropriate light's CCT such as eye strain, or the effects towards emotion and human circadian rhythm(Shamsul et al., 2013).

Illuminance

Illuminance was formerly often called brightness, but this leads to confusion with other uses of the word, such as to mean luminance. "Brightness" should never be used for quantitative description, but only for nonquantitative references to physiological sensations and perceptions of light.

The human eye is capable of seeing somewhat more than a 2 trillion-fold range: The presence of white objects is somewhat discernible under starlight, at 5×10−5 lux, while at the bright end, it is possible to read large text at 10^8 lux, or about 1000 times that of direct sunlight, although this can be very uncomfortable and cause long-lasting afterimages.

Light is a simple part of the electromagnetic spectrum that enables human to see the objects of surrounding. Illuminance is one of the characteristics of light and it is a reflectance of light on subject to human to perform their visual activities. Illuminance (E) is a quantity that used for light incident on a surface and its standard unit is lux (lm/m2) with symbol lx. According to A. R. Ismail (2013), the measurement of illuminance is ratio of luminous flux (lm) to the area of illuminated surface (m2). Several studies have been revealed that bad illuminance can affect the health of people such as causing visual discomfort, fatigue, eyestrain, migraine, and mood changes (HSE, 1997; Boyce, 2003; Hemphälä and Eklund, 2012). Besides that, Caballero-Arce et al. (2012) concluded that inadequate illuminance can also affect humans' alertness and circadian rhythms. Moreover, Juslén (2006) stated that good illuminance can be a positive impact on human performance because it improves the visual performance and visual comfort which affect the productivity indirectly.

At work, people may experience fatigue and a depletion of mental resources. These increased feelings of sleepiness, lack of energy, psychological stress and decrements in performance may be the result of an accumulation of effort spent throughout the working day and of homeostatic and circadian regulation of sleep and wakefulness(Dijk & Lockley, 2002; Kaplan & Berman, 2010). Research has established that light can have both direct and phase shifting effects on the circadian clock(Dijk & Archer, 2009; Zeitzer et al., 2000). Direct effects of light on the human nervous system refer to instantaneous changes in physiological arousal, while phase shift effects refer to temporal changes in the circadian rhythm. In addition to these physiological effects, studies have shown that exposure to higher illuminance levels can result in feelings of increased alertness and better performance(Cajochen et al., 2000; Campbell & Dawson, 1990; Dawson & Campbell, 1991; Lowden et al., 2004; Myers & Badia, 1993; Phipps-Nelson et al., 2003; Rüger et al., 2005, 2006). Importantly, most of these studies have assessed the effect of

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nocturnal light exposure on physiological and psychological measures of arousal and alertness. Moreover, the scarce diurnal data come from studies in which subjects were first substantially sleep and/or light deprived (Phipps-Nelson et al., 2003; Rüger et al., 2006; Gilles Vandewalle et al., 2006). In contrast, little is known about such effects under the conditions many of us live and perform in: during daytime, under normal (or close to normal) sleep pressure, and without hours-long pre-treatment exposure to darkness. Under such conditions, effects may be less pronounced or even disappear altogether, as alertness levels and brain activity may already be optimally tuned to daytime performance, hormonal levels of cortisol and melatonin are already in phase with task demands, and some may already have had substantial amounts of daylight while commuting or during a coffee or lunch break. Although controlled tests of illuminance levels under natural daytime conditions are scarce, a few recent studies do suggest effects of blue-enriched or high correlated colour temperature (CCT) lighting(Barkmann et al., 2012; Mills et al., 2007; Viola et al., 2008). As one exception, Badia and colleagues investigated the effect of illuminance on physiological arousal, subjective alertness and task performance during night time, but also during daytime without sleep deprivation or prior exposure to low illuminance levels (Myers & Badia, 1993).

Results revealed night-time effects of illuminance level on alertness, body temperature, EEG, and performance; in contrast, the results in the afternoon showed a comparable, but non-significant trend. A field study employing fairly subtle differences in illuminance levels (500 vs 700 lx) accompanied by CCT changes (3000–4700 K) during the working day did not render indications of alerting or vitalizing effects of brighter light(De Kort & Smolders, 2010). On the other hand, a meta-analysis by Gifford and colleagues does suggest an effect of illuminance on visual performance tasks with a small to medium effect size(Gifford et al., 1997). Studies on the effect of natural light exposure also suggest that individuals may benefit from higher illuminance levels during daytime and under normal working day conditions in terms of subjective alertness, mood, and sleep quality (Kaida et al., 2006, 2007; Leger et al., 2011), yet such effects are naturally confounded with effects of colour temperature, dynamic light conditions, as well as a view to the outside. In addition to the effects of light on alertness and performance, diurnal exposure to a higher illuminance level might also improve mood. Research has shown that bright light of relatively high CCT improved feelings of vitality and reduced psychological distress of office workers(Partonen & Lönnqvist, 2000), and can be beneficial for people suffering from mood disorders, such as seasonal affective disorder (SAD) (Golden et al., 2005). In addition, short-term exposure to monochromatic light (blue vs. green) during daytime affects activity in the amygdala (and other regions), a brain area related to emotional responses, suggesting that light exposure can influence emotional brain processing (G. Vandewalle et al., 2007, 2010).

Problem Statement

There has been a consistent trend where many offices in Malaysia are facing the problem of a windowless working environment. Once considered a relatively low-key land use in central business districts, the number of serviced offices has increased dramatically in recent years. The factors driving the demand for serviced offices have changed, and the suppliers of this service have reacted quickly to meet these needs. This trend has been assisted by the expansion

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of a select number of multi-national companies that specialise in the provision of serviced offices, available in a flexible range of office types and costs. Office in Malaysia is located at different type of commercial building, example, small office flexible offices (SoFos), small office versatile offices (SoVos), Versatile Office Suites (VoS) and shop offices. Type of office normally depends on the number of employees of the company. Serviced offices are able to offer more flexible rental terms, as opposed to conventional leased offices which may require furnishing, equipment, and more restrictive leases (Becker, 1999; Carter & Al Marwaee, 2009; Reed, Richard and Stewart, 2003). Figure 1.1 shows the number of existing purpose-built office and the number of occupied spaces in Malaysia between 1992 to 2018 (Source: National Property Information Centre (NAPIC).

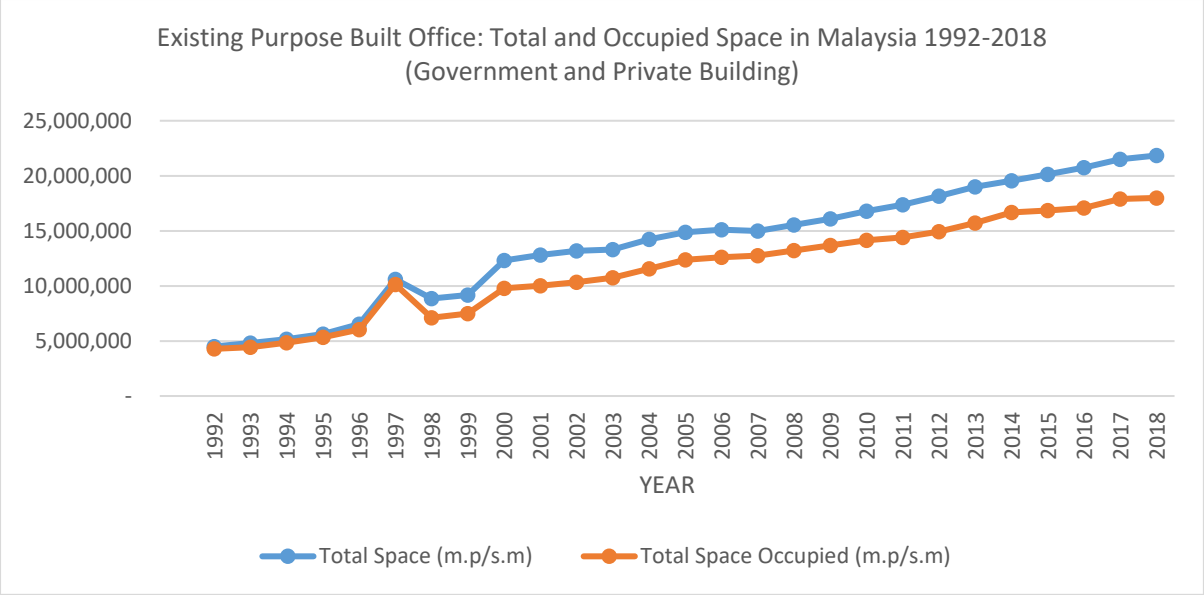

Figure 1 Total and Occupied Space of Built Office in Malaysia Between 1992-2018.

The occupancy rate of office from year to year is above 78 percent. Although the office building is built rapidly, but the occupancy rate is still high. This implies that the better quality of office space is essential for every occupant in the office.

The supply of purpose-built office space provided in privately-owned buildings in Kuala Lumpur increased to approximately 95.9million sqft (8.911 million sqm) last year, based on statistics from National Property Information Centre (NAPIC). Small office flexible offices (SoFos), small office versatile offices (SoVos), Versatile Office Suites (VoS) and shop offices buildings face stringent/poor spatial planning whereby the windows are often blocked by a partition wall for a variety of reasons. Demountable partitions and modular furniture. Facilities owners and office managers are asking for office partitions that will accommodate future moves. Despite the added expense, many office tenants are installing demountable partitions,

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which, along with modular workstations, provide a flexible, open-plan environment that enhances communication and collaboration among employees while making future moves and changes easier (Troukens, 2001). Demountable partitions placed in the office are blocking the window from space to space and become an encumbrance to allow daylight to enter, the space will become gloomy. In a windowless space, the brightness of the space can be relied on artificial lighting. Artificial lighting is crucial especially in windowless working environment.

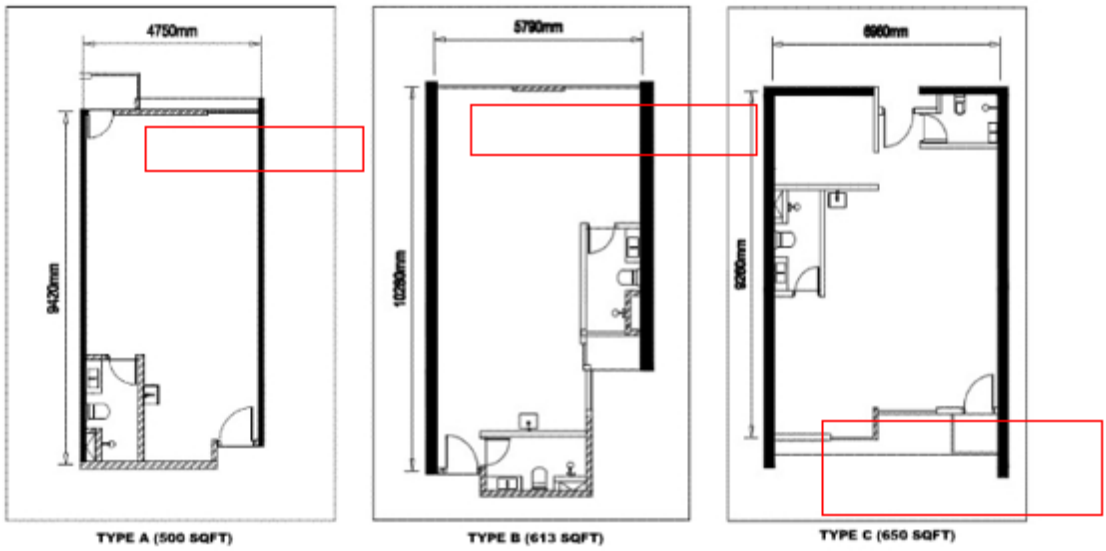

Figure 2 Shop office Batu Tiga, Subang

Source: NewpropertyMalaysia

Figure 2 shows layout plan of shop office at Subang before adding any demountable partition. The red colour box indicates the opening of the office. Once the demountable partition wall is added into the office, daylight will be blocked. This can cause the interior space of the office become gloomy.

Besides high-rise commercial building, shop office is also popular in Malaysia as an office space. Shop Offices usually have been the first option for companies to rent due to the low rental and maintenance criteria, however the limited spaces of shop offices to occupy a lot of office space requirements creates more challenge and problems to the tenants in terms of space planning and flexibility. In Malaysia, the layout of shop offices followed shop houses characters which are long and narrow with limited window opening(Awang & Denan, 2017). According to previous research done by Awang and Denan in 2017 had found out the range of the overall square foot of the shop offices are from 997 sqft to 1626 sqft and the smallest width of shop office is 19’ 4” (5796mm) and the shortest length of the shop office is 49’ 8” (14900mm). Workplace architectural lighting conditions that are biologically dim during the day are causing healthy individuals to experience light-induced health and performance-related problems (Sithravel et al., 2018). There is a problem always occur in intermediate shop office. Side part of the intermediate shop office normally without window, only the front part and the

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rear part of office has window. If the layout of the office is a long layout will occur lack receiving daylighting due to the opening is only located at the front part and rear part of the office. Office occupants seated at the centre part of the office will not be able to obtain natural lighting. Also, natural lighting is not under control due to the unpredictable weather. This leads to the problem of difficulty access to the window and hard to have natural lighting enter to the interior of office, not every occupant in the office have opportunity to sit nearby the window and not every office building exist window. Undeniably, natural lighting can bring plenty of benefits to office occupants, but in different situation, artificial lighting plays an important role to enhance visual comfort.

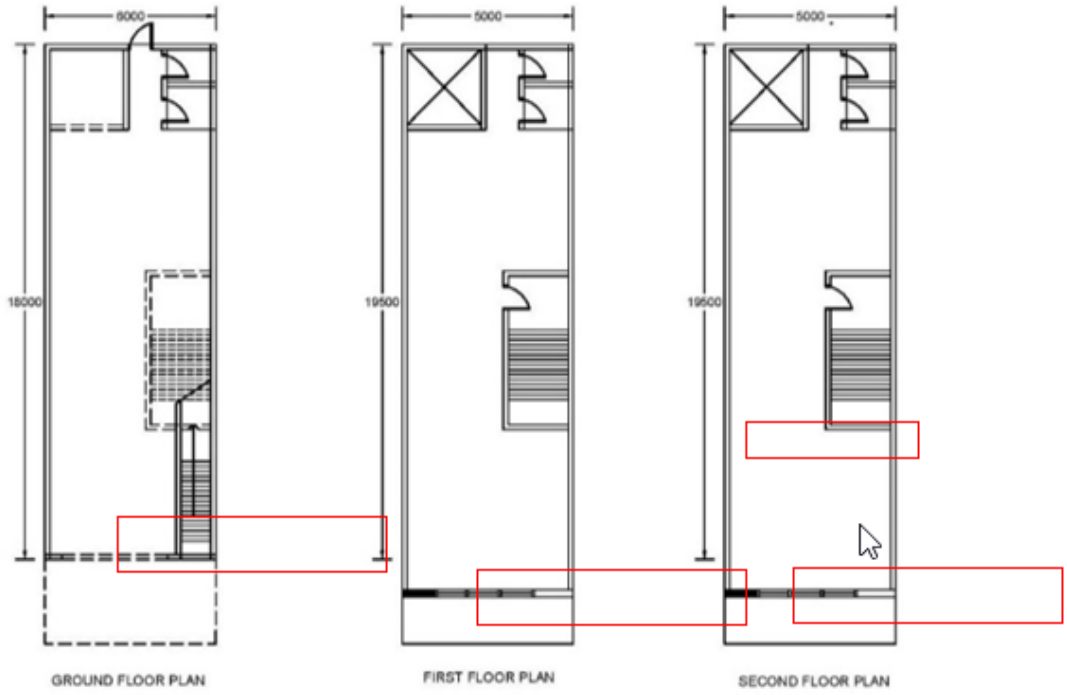

Figure 3 Layout Plan Of 3-Storey Prominence Shop Office, Bukit Mertajam.

Other than the problem stated above, there are some common workplace lighting problems among computer users. Computer is placed on a desk in front of a window can cause glare since that majority of employees are using computer to complete their task. Glare existence in the working environment creates a veil of luminance that reduces the visibility of the target and can have direct or indirect interference with vision. The condition of glare where there is a direct interference with vision is known as disability glare and the condition where the vision is not directly interfered, yet discomfort, annoyance, irritability, or distraction is experienced is called discomfort glare. Disability glare in the working environment causes mental and physical tiredness while discomfort glare affects the individual's possibility to concentrate on the task (Juslén & Tenner, 2005) especially those individuals working on visually demanding tasks such as VDT (Rodriguez et al., 2017).

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Lighting is one of the few environmental parameters that can have an instant effect on the perception and appraisal of a space. By influencing elements such as the intensity, directionality, and the overall luminous balance (balance between the different surfaces of the space), appearances can be changed drastically. Moreover, the effects of lighting are not limited to appraisal and atmosphere perception, as studies have indicated that different lighting conditions can also trigger changes in mood and emotional state (Fleischer et al., 2001; Knez, 1995; Knez & Kers, 2000; Rikard Küller et al., 2006) which, depending on context, may lead to changes in behaviours (de Vries et al., 2018).Visual discomfort can affects human not only physiological but also psychological strain such as anxiety, fatigue, lethargy, headaches, eyestrain, migraine, nausea, back pain, neck pain, shoulder pain, poor concentration or lack of mental alertness, and daytime sleepiness among VDT workers are primarily connected with inadequate lighting in the working place and in most cases decrease work performance and efficiency (Pauley, 2004). Office employees focus on the computer screens for many hours in a day. They do not have the opportunity to look at the natural elements outside the windows. The eye muscles contracted when focusing on the tasks that are visually intense, such as the focus on a near distance object. This will irritate the workers' eyes and make their eyes feel uncomfortable. However, eye strain is a common phenomenon in the office. A large amount of research has identified that lighting also exerts nonvisual effects on biological rhythms, commonly known as body circadian cycle (Hoffmann et al., 2008; Stevens et al., 2013).

In the year 2002, David Berson noted that apart from traditional photoreceptors (rods and cones) typically responsible for vision, in mammals' retina, there is another photoreceptor called intrinsically photosensitive retinal ganglion (ipRGC) (Pauley, 2004). This is a part of the suprachiasmatic nuclear (SCN) of the hypothalamus (van Bommel & van den Beld, 2004) which is a section of the brain that controls the body circadian cycle and is mostly involved in several nonimage forming functions such as promoting alertness, mood, cognitive performance, controlling body metabolism, DNA damage response, hormone production, and even cell cycle regulation and division (Kruisselbrink et al., 2018; Stevens et al., 2013).

Apart from the issue of having employees who are unenergetic, this could also lead them to make the wrong judgment, get easily distracted, and affect their ability to handle stress as well. Other than that, most of the office walls are all in white or beige. This creates a mundane atmosphere to the employees. Employees are not permitted to change the colour of the walls, but it is unfathomable that they have to put up with this kind of stressful working space. This will affect the productivity of the workers as many of them might feel demotivated.

Thus, providing adequate or quality lighting condition in a working space goes beyond the act of just installing a suitable quantity of light. It involves many factors including illuminance uniformity, luminance distributions, light colour, colour rendering and colour temperature characteristics, nature of light (natural or artificial), flicker, and glare control among others (Technical Committee CEN/TC 169 "Light and Lighting," 2002; Veitch & Newsham, 1998b).

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Results and Discussion

Visual comfort is an important indicator of both occupant satisfaction and work performance. The correct design of an illumination system should offer the optimal conditions for visual comfort. The combination of illumination, the contrast of luminances, the colour of light, the reproduction of colour or the selection of colours are the elements that determine colour climate and visual comfort. The lighting illuminance level and uniformity refer to the maintained minimum average illumination required to accomplish a specific task in a given work plane(Lee et al., 2014). Most of the lighting codes from different parts of the world such as the Malaysian Standards (MS1525:2014) specify that recommended illuminance level for the interior of general offices, shops and stores, reading and writing is 300 to 400 lux and minimum CRI is 80. Researches point out that right illuminance level and uniformity improve occupants' visual perception and decrease the signs of fatigue, including eye pain and headache(Lee et al., 2014; Wessolowski et al., 2014). Also, well-maintained illuminance levels increase occupants' mood and alertness (reduce sleepiness) which are essential factors for increasing occupants' performance(van Bommel & van den Beld, 2004).

The correlated colour temperature (CCT) and colour rendering index (CRI) of the light source dictate the way the light is perceived in a given space. Both CCT and CRI play a dynamic role in addressing the psychological and physiological functions of the occupant(Kralikova & Wessely, 2016). CCT of the light source influences visual perception and is significantly linked to visual satisfaction, mood, cognition, and comfort (Lee et al., 2014). According to Meloy and McLeod (McLeod, 2007; Meloy, 2000), cognition is a mental process of acquiring knowledge and understanding through thinking, knowing, remembering, judging, problem-solving, reasoning, comprehension, and attention. Thus, applying appropriate CCT in the working environment enhances occupants' motivation, improves health and cognition, increases working efficiency, and hence improves productivity. Existing researches have also identified that occupants subjected to daylighting working environments exhibit higher work satisfaction and excellent performance (R. Küller & Wetterberg, 1993).

An integrated lighting design method is needed to improve occupants' job satisfaction. This design gives users the freedom to control the lighting in their office. User-centric lighting design is the ideal solution to improve user health and sustained good performance. This kind of lighting design is also used in (Behar-Cohen et al., 2011; Jamrozik et al., 2018)as an efficient method to improve occupant's visual comfort, work environment satisfaction, and work efficiency.

Lighting control enables the space to be properly illuminated for the safety and comfort of the user. It need to operate in a way that is appropriate to the type of space and needs or expectation of the users (Littlefair, 2006). Inadequate controls can lead to physical injuries due to poor illumination, for example, from tripping or falling in an unlit space. They may also frustrate users who cannot control their environment effectively, especially in a space where it would traditionally be expected. For example, if occupancy sensors are not positioned correctly and do not turn on or off as expected, people will soon become irritated. These factors can add to stress. Where users do have some form of individual control, issues may arise from a lack of

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training or inappropriate control interfaces. Not understanding how to use the control leads to confusion, errors and frustration. Training and user knowledge of the system is an often overlooked aspect of design (Yılmaz et al., 2016).

Conclusion

Thus, providing adequate or quality lighting in a working space goes beyond the act of just installing a suitable quantity of light. It involves many factors including illuminance uniformity, luminance distributions, light colour, colour rendering and colour temperature characteristics, nature of light (natural or artificial), flicker, and glare control among others (Technical Committee CEN/TC 169 "Light and Lighting," 2002; Veitch & Newsham, 1998). Having a good visual comfort in the workspace play a significant role affecting the employees mental and physical health. The inexistence of window of shop office or soho office is a common problem faced by office occupants, especially in Malaysia. So, the only effective way to increase visual comfort for the employees is to find out the most appropriate artificial lighting in the office. This is easy to achieve in windowless offices in Malaysia based on the illuminance of lighting and correlated colour temperature (CCT) to improving occupants' satisfaction, morale, well-being, and work productivity.

The results have indicated that workers are less satisfied with their offices' lighting environment. Physical measurements and researchers' observations also depicted that the quality of the illumination was insufficient for a healthy working environment. Visual comfort in the office environment is a space that is designed to be visually comfortable. With a proper lighting configuration to place in windowless office, it may help the employees to boost their productivity, reduce stress and increase their creativity. Every lighting should be placed in a proper position so that it can achieve the best results to the employees who work in a long and narrow shophouse office with poor lighting.

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