

Work Productivity and Human Wellbeing in Offices Using Natural Light Vs Artificial Light

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Abstract

Recent studies have proven that lighting conditions in the workplace play a vital role in employees' satisfaction as well as their productivity, and health in general. Natural light is the main source of lighting in the workplace, and it's very important for the employees to be exposed to it to a certain level in addition to the artificial ones. This paper reviews the important role of lighting in the workplace with regard to shedding light on natural lighting, how employees feel about it and about lighting in their offices in general, and whether it causes a certain health issue or not. This was done by surveying several employees from different companies and was supported by a correlation analysis study to study the relationship between the different parameters. An experiment was conducted to check if the employees were exposed to healthy and safe lighting in different locations depending on different parameters and indications such as lighting steadiness and distribution, and whether they faced common issues such as glare, lighting contrast, and flickering. New and old buildings have to incorporate natural light more into their structure. A review of possible solutions has been created and made for both with some innovative solutions.

Keywords

Natural lighting, Artificial lighting, productivity, alertness, circadian rhythm

1. Introduction

Huge efforts are made to make office environments as healthy and safe as possible to ensure the satisfaction of employees and maximize the performance of the company. Conditions such as lighting, temperature, ventilation, cleanliness and ergonomics are key indicators of the safety and comfort of any workplace. Lighting conditions play a huge role in this formula of safe workplaces. Poor lighting at work can cause health issues such as eye strain, headache and fatigue as well as low performance. In addition, too much light causes safety and health issues such as glare and stress which can lead to mistakes and lower the quality of work. Good lighting conditions reduce the risk of occupational accidents and health problems and increase concentration and accuracy of work. Artificial lighting is usually considered to be the dominant source of lighting in offices worldwide due to the reliability, wide range and options they provide. However, excessive use of artificial lighting with no natural lighting possesses a health risk to the employees. Lack of exposure to sunlight during working hours can be concerning especially over a long period of time. This paper reviews the health benefits of exposure to natural lighting in offices as well as comparing between the characteristics of artificial and natural light. In addition, the paper tests the importance of natural lighting along with assessing the lighting conditions in different office environments.

1.1 Objectives

- Provide evidence of the importance of using natural light on employee's wellbeing
- Increase employee's productivity and satisfaction through studying lighting conditions in offices
- Recommending optimized, innovative and cost-effective solutions to improve lighting conditions

2. Literature Review

2.1 Nature of light

According to the Scientific Committee on Emerging and Newly Identified Health Risks, Light is considered a human's primary means of perceiving the world and interacting with it and can be defined as the electromagnetic radiation that can be detected by the human eye. It has a narrow window in the electromagnetic radiation spectrum ranging from 400 nm wavelength to 700 nm. Radiations below the wavelength of visible light are considered high energy photons such as UV, x-rays and Gamma rays. Lower energy photons have a longer wavelength than visible light such as IR, microwaves and radio waves. Light is made up of photons which are tiny particles that carry a specific amount of energy and are produced from the movement of atoms caused by heating. The number of photons irradiated from a light source affects the intensity of that light. Light intensity is the rate at which light spreads over a surface from a given distance.

In the scientific context, the amount of light falling over a surface is called illuminance and is measured by light meters which gives the amount in Lux (McCluney 2003). Another important factor affecting the perception of light is the correlated color temperature (CCT). Color temperature describes the appearance of light from a light bulb and is measured in Kelvin and is given a scale between 1000K – 10000K. Temperatures of commercial lighting applications lie between 2000K and 6500K. At the lower end of this range, the produced light is called warm white, and it appears orange or yellow white. Higher temperatures give cooler light with a tint of blue until it reaches a "daylight" zone at 4500K. Color temperature is an essential factor in determining the mood of a living space and largely affects productivity (Wang et al. 2017).

2.2 Lighting technology milestones: incandescent lamps, fluorescent tubes and LED

The technology of light bulbs has evolved tremendously over the centuries and for reasons such as efficiency, sustainability and health. There are three main milestones in light bulb technology that have made the use of non-natural lighting more common and cost effective. Those three technologies are incandescent lamps, fluorescent lamps and LEDs. Incandescent light gets produced by heating a filament inside a glass bulb to a certain temperature which generates heat. They're considered cheap to manufacture and purchase and are adaptable to a large range of voltages and currents.

However, incandescent lamps are very inefficient (90% of energy is transformed into heat) and they have a relatively short lifespan (around 1200 hours). This led to the invention of a more efficient solution, the fluorescent lamp. A fluorescent lamp works by a chemical reaction that involves mercury and inert gases that interact after current goes through them, generating invisible Ultraviolet light. This UV light then illuminates the inside of the fluorescent tube, which is coated with phosphor, which then emits white light. Fluorescent lights produce less heat than incandescent light and are four to six times more efficient. In addition, fluorescent lights can give cooler color temperatures (up to 6500K), which is best to illuminate metro stations or hospital hallways. Moreover, they're more affordable than their more efficient LED counterparts. Fluorescent lights are commonly used in places where saving energy with the minimal up-front cost is required. This includes commercial offices, warehouses, hospitals, classrooms and retail stores.

There are several disadvantages of fluorescent lights that need to be considered as well. Fluorescent lights can be harsh on the eye, especially the inexpensive ones, causing several problems when exposed for a longer period. These problems include eye strain, headaches, blurred vision, burning and watery dry eyes. In addition, an imbalanced reaction in fluorescent lights can cause color shifting of the light after a few hundreds of operating hours, resulting in poor lighting and less bright areas. In addition, one of the most critical drawbacks of fluorescent lights is the environmental impact. As known, fluorescent lights contain toxic materials such as mercury and phosphorus. When a fluorescent light breaks, a small amount of mercury can be released as gas contaminating the surroundings. Moreover, disposal of fluorescent lights can be a challenge because of such toxic materials and it poses additional expenses to ensure proper recycling and minimum effect on the environment.

The third and most recent technology in artificial lighting is the light emitting diodes (LEDs). LEDs emit light when electric current flow through a semiconductor by the movement of electrons. The color of LEDs is directly related to the semiconductor material used in them. For example, blue, green and ultraviolet high brightness LEDs use Indium gallium nitride as a semiconductor while yellow, orange and red high-brightness LEDs use Aluminum gallium indium phosphide. LEDs have many applications such as lighting up digital clocks, TVs and phones. In lighting, LEDs are considered the most efficient solution since it generates very little heat compared to fluorescent and incandescent. In addition, they emit light in a 180 degrees direction, unlike the fluorescent light which emits light at 360 degrees, which means less light is lost from the need to redirect the light. Moreover, LEDs have lifespans that extend up to 100,000 hours, making them a very cost-effective solution in the long run. They are widely used in streetlights, parking garages, warehouses, residential houses and offices. The widespread use of LEDs is expected to increase even more due to the reduction of manufacturing costs (Montoya et al. 2017). The main disadvantage of LED lights is that they might exceed the safe limit of the blue light hazard as defined in eye safety specifications. Such hazard is believed to cause damage to the retina if exposed frequently. The blue components of white LEDs may cause retinal toxicity at occupational domestic illuminance, not only in extreme conditions (Krigel et al. 2016). Such hazards are yet to be identified and current regulations and standards are not in line with these findings.

2.3 Effects of light on human health

Recent studies have proven that workers at offices may experience discomfort and some severe health issues at their workplace, where they spend around 8 hours of their day in closed areas. These issues may arise for many reasons, including lighting, temperature, humidity, air environment, noise, culture, and air quality. Of these mentioned reasons, some studies suggest that lighting conditions are the most influential factor (Elias et al. 2017). Light and its effects can be categorized mainly into two categories, the first is the visual effect of light, which we perceive through our eyes. This enables us to communicate and interact with the outer environment through a special light-sensing system with a photoreceptive retina that consists of cones that see the bright light and are responsible for day vision, and the rods that see dim light and are associated with night vision.

When light reaches the retina, it gets converted into an electrical signal that gets transmitted to the visual cortex through the optic nerves, which allows us to sense the world around us (Tossa et al. 2019). The non-visual effects of light have physiological, psychological, and behavioural influences. In addition to the photoreceptors mentioned earlier, the rods and cones, there are special types of light-sensitive cells called ipRGC (Interictally Photosensitive Retinal Ganglion). This special type of cell is involved in many non-image-forming functions such as cognition, mood, concentration, cognition, and alertness.

These unique cells are found in the hypothalamic suprachiasmatic nuclear (SCN), which is the region of the brain that regulates the body clock (Circadian Clock). It regulates and monitors a variety of physiological activities that are affected by a circadian rhythm, including hormone levels, for example, melatonin, the sleeping hormone, serotonin, and cortisol (Slegers et al. 2012). Cortisol levels rise in the morning, preparing the body for action, according to the cycle of these hormones and their role in the human body. These levels then progressively drop but stay high enough to supply energy and blood sugar to the body throughout the day, before dropping to their lowest point around midnight. Melatonin levels, on the other hand, drop considerably in the morning, lowering tiredness. Under typical circumstances, when daylight fades to darkness, the levels rise again, allowing for healthy sleep. Furthermore, the serotonin hormone is important in balancing melatonin during the sleep process, as well as in the maintenance of emotional states and mood control (Konstantzos et al. 2020).

Lighting has a good association with improving the mental health of the workers. It improves the mood, lowers eye strain that results from poor lighting conditions, as well as lowers fatigue and tiredness and enhances morale. Thus, companies should consider making changes and investing in them if they have been shown to improve employees' positive energies and moods. According to studies, providing appropriate and healthy lighting improves work performance and affects job satisfaction, as well as increases production, improves welfare, and lowers absence rates, resulting in a quick return on investment (Deng et al. 2021).

2.4 Natural light VS Artificial light

Lighting in offices can mainly come from two different resources, which are the natural light coming from the sun and the artificial light manufactured by humans with the different types as mentioned earlier. According to studies, there are some core differences between natural light and the artificial light provided by fluorescent and LED bulbs, which makes the natural light more needed and has to be provided in sufficient quantities to their employees. The

main differences are that natural light consists of a balanced spectrum of colors that humans need for their daily activities and has the highest and most efficient light level that ensures the biological functions, metabolisms, and the balanced circadian cycle, while artificial light lacks the blue portion of the spectrum and excessive exposure to it can lead to sleep disturbance and an increase in stress level. Many studies were conducted to further study the effect of daylight and its importance for humans. Natural light is able to influence cognitive performance through its synchronizing and phase-shifting impacts on the circadian clock. As a result, exposure to natural light impacts brain cognitive performance, memory, and attention (Bommel et al. 2004).

2.5 Studies to Examine the Importance of Natural Light

Recent studies have proven that natural light exposure improves sleep quality for workers. A study looked at the role of self-regulatory variables such as exhaustion, mood, behavioural patterns, and psychological self-regulation as modifiers of seasonality in sleep time for 162 young people in Norway. The findings show sleep time has been delayed during the dark season in months like December compared to seasons where sunlight is more available, such as September and March. They have also reported cases suffering from anxiety, depression, and exhaustion with lower levels. Furthermore, the circadian cycle was disrupted by insufficient daylight caused by melatonin production at inconvenient times of the day (Jamala et al. 2019).

Table 1. Natural Light and Human Body

Physically		Psychologically	
Improve	Decrease	Improve	Decrease
Vitamin D	Cancer Possibility	Mood	Depression
Visual System	Abnormal Bone Formation	Mental Performance	Stress
Circadian Rhythms	-	Alertness	Sadness
Sleep Quality	-	Brain activity	Violent Behavior

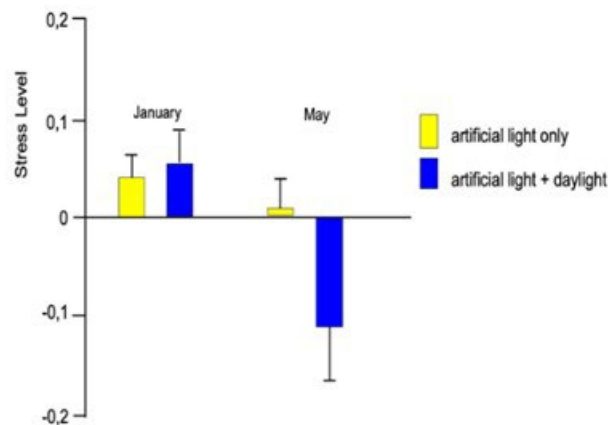


Figure 1. Stress complaints

Furthermore, the study shows evidence of the effects of light on attitude and mood. Lack of natural light can cause a special type of depression called seasonal affective disorder, which is found among people living in areas such as northern latitudes and can cause alertness and sleeping issues. It is developed due to the insufficient amount of daylight and, according to Avery and colleagues, more than 10% of the population of Finland and about 6% of the population of the United States experience this seasonal disorder. Another benefit of daylighting is that its intensity varies

throughout the day and seasons. The impact of varied lighting conditions on subjective mood in an experimental office, according to a study conducted by Hoffman and his colleagues, varying lighting levels had a potential advantage for office workers in terms of their subjective mood. Meeting our urge for interaction with the outside world through daylight apertures in buildings is another essential psychological element of daylighting. Because it provides a view of the outside world, daylighting has a natural healing impact in this regard. Daylighting can help people feel more connected to nature and boost their mood (Ishii et al. 2016). Table 1 shows the physiological and psychological benefits resulting from building daylighting. Figure 1 shows the stress complaints in offices due to lighting.

Natural light and views of the nature, in general, were rated as among the top five most wanted characteristics of the workplace environment as indicated in a recent study of office workers in over 16 nations from different parts of the world, however, 47% of respondents said they don't have natural light access and as a result of that they suffered stress and depression (Vega et al. 2022).

2.6 Daylighting in Offices

Workers who work in spaces that have daylit and full-spectrum office buildings often report an increase in their well-being and satisfaction. This environment provides a better healthy light condition, and it allows workers, whether working on a day or night shift, to adjust their circadian clock, reducing absenteeism, increasing productivity, financial savings, decreasing accidents, and increasing levels of mental health and performance, and improvements in sleep quality. The benefits to office workers exposed to daylight are so significant that many European countries require workers to be within 27 feet of a window. Companies have started paying attention to the importance of daylight. For example, VeriFone, Inc. built a new daylit Worldwide Distribution Centre and claimed higher productivity a year and a half after putting it into service. The reported results showed that productivity grew by more than 5% among employees, and overall product output increased dramatically by 25%–28%. In addition, increasing productivity may lead to an increase in financial savings. Reno Post Office investigated the effect of providing adequate daylight, which helped them gain from 400,000 to 500,000 dollars (Rea 2015).

Lighting ergonomics in the workplace should be considered when designing buildings and providing various lighting sources, as it has a significant impact on personal well-being and health in general, as well as productivity and performance. It must be designed based on ergonomic principles and comply with HSE codes and standards. Figure 2 shows the different parameters of illumination that needs to be considered for a well-lighted ergonomic workplace (Hubalek et al. 2010).

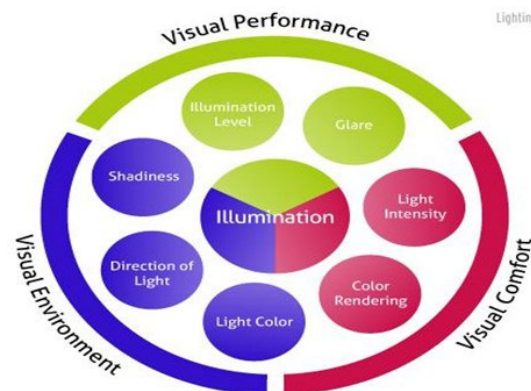


Figure 2. Parameters of illumination

3.8 HSE regulations

OSHA has specific regulations regarding the minimum level of illuminance in certain commercial areas such as:

- Offices, laboratories, showrooms and retail locations: 500 lux
- Factories, workshops and auto shops: 750 lux
- Warehouse loading bays and areas of ingress/egress: 300-400 lux
- Lobbies, corridors, stairwells and common areas: 200 lux
- Warehouse aisles: 100-200 lux

3. Methods

To study the effect of lighting conditions on employees' wellbeing and productivity, compare natural and artificial lighting conditions, and support the importance of natural light, a survey has been conducted with a total of 16 questions and 62 responses were collected across different companies in UAE. The questions covered some main areas, such as how satisfied the workers are with their lighting conditions in the office, and whether the lighting causes some issues, including eye strain, headache, stress or depression, and sleeping issues. In addition, several other questions were asked to check the preference of the workers whether they prefer natural or artificial lighting and whether they are being exposed to natural lighting sufficiently. Other questions cover lighting ergonomics, including lighting distribution and steady illumination. Workers at offices using their computers may suffer from different issues such as glare and improper contrast. Additional questions that tackle these aspects were covered in the survey. The survey's questions covered 2 main areas the first one is the importance of natural light, and the second is studying lighting conditions in work offices in general.

In addition to the survey, another method has been conducted to assess lighting conditions in the work environment. A special device which is the light meter was used to determine the quality, intensity and consistency of lighting. The experiment was done in NPCC offices and within different time periods and under a variety of conditions, including natural lighting, artificial lighting and a combination of both. Two environments were the subject of the experiment, one is a closed office with windows and the other is open space cubicles with no windows.

4. Data Collection & Survey Results

Importance of Natural lighting

One of the main questions that were asked was whether the workers get enough exposure to natural light in their office areas, and the scale was from 1 to 5, where 1 indicates the lowest exposure and 5 is the highest. The results, as indicated in Figure 3, show that the majority of 32.2% have sufficient access to natural light. However, 30.6% as well answered with a low range of 1 & 2 for not being adequately exposed to it. Other significant questions were asked to check how important it is for the employees to have access to natural light in the offices. The results as shown from Figure 4, 59.7% for the rating of 5 and 32.2% for the rating of 4, for a total of 92% of the respondents believe that having enough exposure and access to natural light is a very important thing that has to be available in the office environment. In addition to that, other outcomes have been addressed to check the workers' preference of whether they prefer having natural lighting resources in their offices other than artificial ones. The results, as illustrated in Figure 5 show that around 85%, strongly prefer having natural lighting resources to be dominant in the offices, and when the workers were asked if they believe that providing natural light contributes to and affects their alertness, concentration, and productivity, 82.3% strongly agreed with the statement. Recent studies have shown that being exposed to natural light increases the productivity and alertness of workers due to its influence on melatonin. 88% of the respondents want the new building to have more exposure to light due to its importance and great contribution to employees' overall satisfaction.

Working offices' lighting condition

Studying the lighting conditions in offices can give an indication of how healthy our workplaces are in terms of providing the most efficient and suitable conditions for workers in order to perform and function well. One of the main indicators of poor lighting is the health issues associated with it. When workers were asked whether the lighting in the offices causes them to have and develop certain symptoms such as eye strain, headache stress or depression, the majority, representing 50% of the response, don't suffer from them. (Figure 6)

However, 25.4% state that lighting does cause them these problems, which is a critical percentage that should not be neglected and should be addressed. Lighting ergonomics involves many other criteria and aspects, such as lighting steadiness and lighting distribution among the spaces. When asked about steady illumination, as shown in Figure 7, 58.1% of the responses believe they have steady illumination throughout the whole working day, while 12.9% suffer from lighting unsteadiness. Moreover, 50% declared they have evenly distributed lighting in their offices, while 12% of the workers suffer from the improper distribution of lighting, as shown in Figure 8. A glare, which is a visual discomfort sensation caused by excessive and uncontrolled brightness, is also a measure of lighting efficiency, particularly for those who use computers to perform their tasks. When workers were asked if glare from artificial lighting bothered them. 61.3% answered with a high rating of 4 and 5, indicating that they do suffer from it while doing their computer tasks. Glare can lead to a serious eye related diseases such as cataracts and macular degeneration

if workers face it for a long period of time. Improper contrast from different resources from the room and computer screens as well as the blinking lights also cause discomfort and other related health issues in the long term. As shown in Figure 9, 45.1% state that they do face these issues while doing their usual computer tasks, and this is considered a high percentage that companies need to take care of. The two other important factors that are affected by lighting conditions inside the offices are sleeping patterns and disruptive sleeping, and the other one is the overall mood of the employees and the dominant state of feelings that they experience when workers were asked whether lighting conditions affect their sleep and cause disruptive sleeping. As indicated in Figure 10, employees were asked whether lighting affects their mood or not and 66.2% stated that their mood is strongly affected by the lighting conditions in their offices, while a small percentage of 19.3% find that it doesn't have that huge impact. When workers were asked whether lighting caused them to have disruptive sleep, 37.1% responded with a score between 4 and 5, which is considered a high percentage, indicating the significant impact lighting has on workers' circadian rhythm and sleep. (Figure 10)

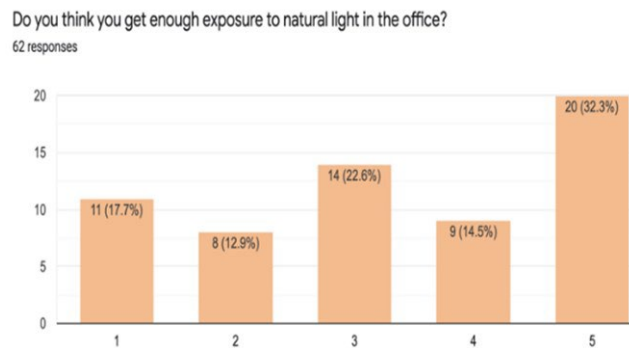


Figure 3. Natural light exposure

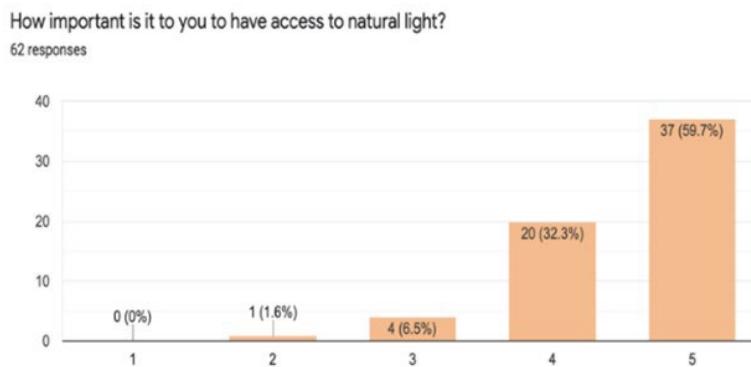


Figure 4. Importance of access to natural lighting

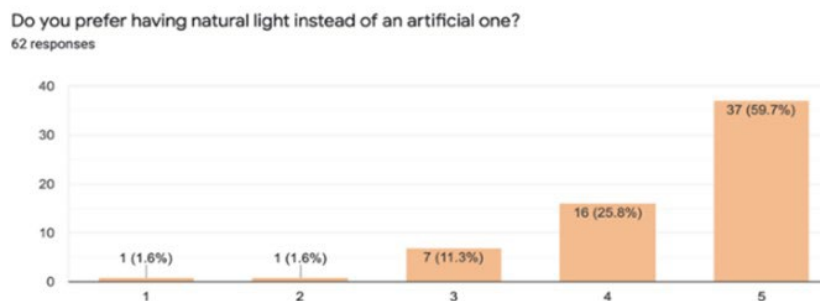


Figure 5. Employees preference between natural and artificial lighting

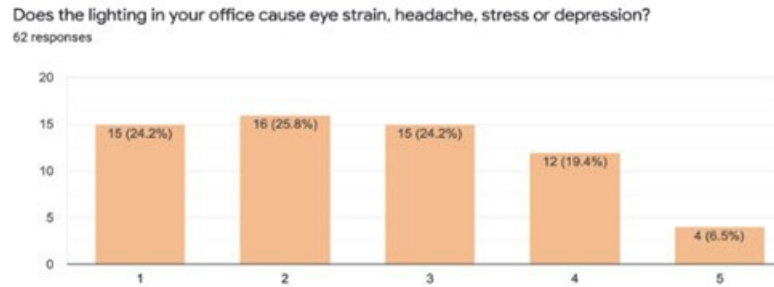


Figure 6. Lighting and health-related issues

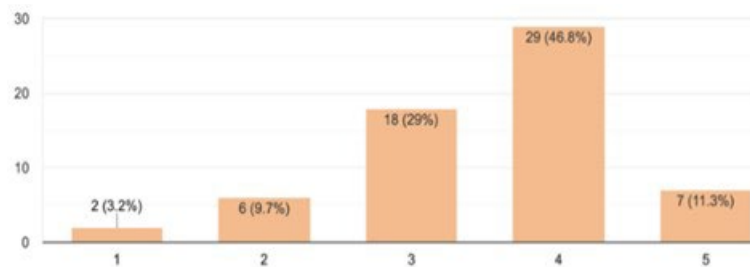


Figure 7. Lighting steadiness in workplace

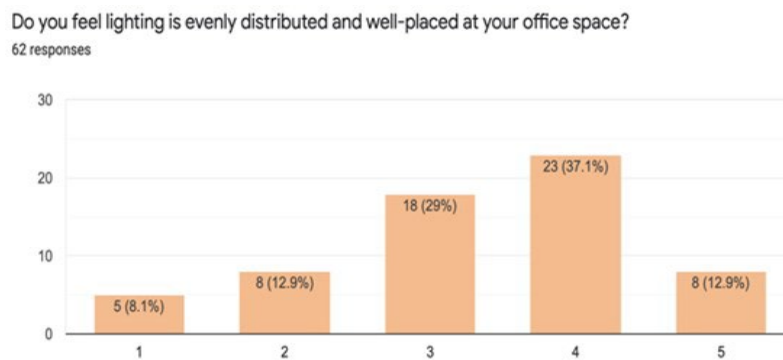


Figure 8. Light distribution in offices

Do you suffer from improper contrast (low light from the room and bright light from the computer screen) and flickering (blinking) lights?

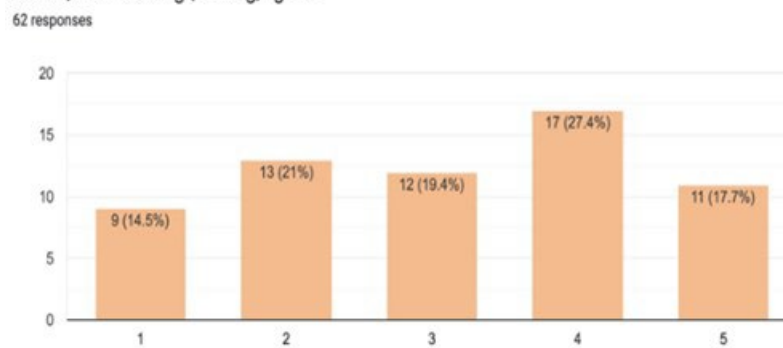


Figure 9. Lighting contrast and flicker

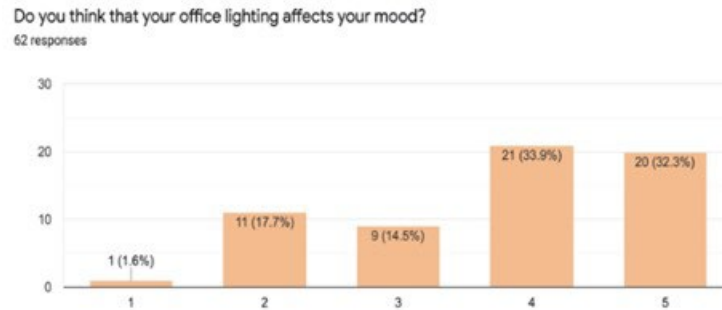


Figure 10. Effect of lighting on employee's mood

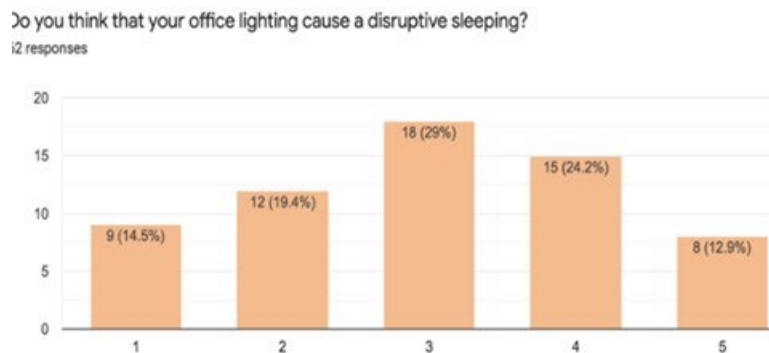


Figure 11. Does lighting cause disruptive sleeping?

5. Results and Discussion

5.1 Survey Correlation Analysis

After collecting the sample responses and studying the ranges of the answers, and identifying some major points and critical areas, correlation analysis has been done to study the relationship between the different aspects of the survey's questions.

One of the good relations that has been captured from the analysis is the relation between workers getting enough exposure to natural light vs. how satisfied they are with their current lighting conditions. The results show a correlation of 0.57. This gives a positive good moderate relation between natural light exposure and the employees' satisfaction. Where getting enough exposure increases their wellbeing and their overall satisfaction in their workplace. This supports the study that has been covered in previous research. For example, one frequently cited Harvard study shows that Future Workplace Employee Experience Study found that 78% of employees say access to natural light and views improves their wellbeing and 70% report improved work performance. Another relation is considered to be important from the analysis is the relationship between worker's satisfaction and whether the lighting condition of the office cause some health related issues such as eye strain, headache, stress or depression. The results show a relation of -0.52 which is a negative relation, where it is clear that the current lighting condition doesn't have cause and lead to these issues and this can be a result of two main reasons the first one is that employees are not fully aware of their lighting at offices, and the second reason might be because of the huge efforts that companies invest in to make their lighting good and suitable for their employees. The other relationship to be highlighted is the relationship between workers' preferences to choose between natural light or artificial light and whether they believe that natural light increases their alertness, concentration, and productivity. The results show a moderate relation of 0.41 where workers who chose to have more exposure to natural light believe that it increases their productivity, concentration and alertness. There is another relationship that can be highlighted is between getting enough exposure to natural light, and whether lighting causes eye strain, headache, depression or stress, and the relationship is equal to -0.51. A moderately good relation indicates that employees do have adequate natural lighting to minimize these health issues.

5.2 Office lighting measurements

The assessment of the lighting conditions in NPCC offices showed that closed offices had better lighting in all conditions, with the numbers falling within the recommended office lighting (300-500 Lux). The natural light in the office was lower than expected due to the location and design of the office and the size of the windows. The windows were shaded as well, reducing the readings even more. A combination of both artificial and natural was optimum for that environment and could result in better wakefulness and productivity, as well as mood improvement. The cubicle environment studied in the experiment had no natural light access from any direction, making it fully relying on artificial lighting to provide vision to the employees. Such design increases the probability of poor lighting conditions, especially when the lighting is subject to failures. This observation indicated that the lighting is not well distributed within the offices, which can lead to lower performance. Natural light, especially for open spaces, is crucial to compensate for the artificial lighting disadvantages that could occur suddenly, such as flickering, different intensity and glare.

Table 2. Lighting conditions measurements

Time	Closed Office			Cubicle		
	Artificial	Natural	Combination	Artificial	Natural	Combination
10:00 AM	413 Lux	37 Lux	424 Lux	215 Lux	0 Lux	215 Lux
2:00 PM	433 Lux	143 Lux	512 Lux	204 Lux	0 Lux	204 Lux

5.3 Proposed Improvements

Our recommendations focus on providing the best tools and technologies that provide enough natural light for workers to be exposed to in their offices. We focused on providing more access to natural light in both the new building as well as existing buildings.

Lighting in new buildings:

There are several design considerations that can be implemented in the initial stages of building construction to ensure proper access to natural lighting such as:

- Orientation: For optimization of daylight and ensuring maximum and uniform natural light exposure, buildings footprints must maximize south and north exposure, and minimize east and west exposure as shown in Figure 12. This orientation allows for consistent and soft light throughout the day and seasons.
- Proper floor depth: having a proper length in the range of 17 – 19 m from south to north ensures 90% daylighting for the whole floor, given proper window design.
- Climate responsive window to wall ratio: Balancing between the admission of daylight and heat by following the standard 90.1 set by The American Society of Heating, Refrigerating, and Air Conditioning Engineers, as well as using spectrally selective films to admit more sunlight and less heat.
- Using windows, skylights, and solar tubes whenever possible.

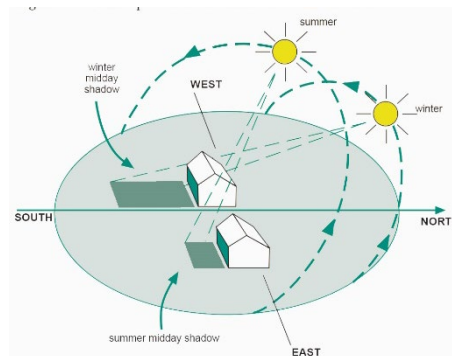


Figure 12. North & South facing building

Lighting in existing buildings

To increase exposure to natural lighting resources, many tools and technologies can be implemented and added to existing buildings. technologies and tools involve:

- LightBox therapy (Dynamic lighting): This is a tool used to mimic the condition of outdoor light. They are used to treat people suffering from seasonal affective disorder (SAD). This technology can be more often available in the offices to be provided to the workers when needed. It causes a chemical change in the brain that lifts and enhances the mood's quality. It can provide exposure to 10,000 lux of light.
- Sky ceiling: We can use this technology to recreate real natural views of the world with a real window appearance in the ceiling of the rooms.
- Light wall colors: Special types of paints also can be used that reflect the natural lighting in the best way.
- Install smart lighting adjustment systems: These smart systems can help in adjusting the lighting conditions based on employees' preferences and the tasks being performed.

Project limitations and further improvement

There were some limitations in the study conducted to test the importance of natural lighting. The survey sample is relatively small. A larger sample could provide better results and correlations between the questions. In addition, improvements can be done to the experiment by testing other lighting-related measurements such as correlated color temperature, lighting direction, shadiness, and color rendering. Furthermore, the experiment can be further developed by matching the lighting conditions in NPCC to the health conditions of the employees. This can be done by using biological assessments such as blood tests, urine and saliva to test the hormone levels of the workers.

6. Conclusion

Studies have proven the importance of natural light and its effects on workers to increase productivity, and alertness, improving their mood, and overall mental and physical health. Our paper supported the high impacts of natural lighting on employees from various industries, with the survey results demonstrating a very good result in terms of studying the importance of having more access to natural lighting, its effects on employee satisfaction, and its impact on the overall performance of the workers. Moreover, lighting conditions, in general, have to be taken into companies' consideration in order to provide the best possible environment for their workers. The experiment was conducted to check if the lighting conditions in NPCC offices fall within the range of the recommended illuminance in office areas, and the results show that some areas such as the cubicle don't have a good amount of lighting. They lack exposure to natural lighting. Our recommendations focus on providing the best possible lighting conditions using different tools and technologies in both the existing and new buildings. There were some constraints in the research that have been identified, they can be further addressed, and further actions can be taken in order to have more intensive and precise results.

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