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Optimising the usage of artificial lighting for managing sleep disorder among Universiti Sains Malaysia students

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ABSTRACT

Nowadays, students spend more time inside, and their exposure to artificial light increases. This light regulates circadian rhythm, an essential element for improving the environment and providing better illumination. Nevertheless, inadequate artificial lighting settings with improper illumination spectrum and colour temperature may disturb the circadian rhythm and impact sleeping habits. Researchers need to examine artificial lighting sources based on light fundamentals in order to enhance sleep quality, particularly for individuals who keep lights on while sleeping. To improve sleep quality, researchers must analyse artificial lighting sources based on light fundamentals, and lighting product current. The study aims to optimise artificial lighting environments for individuals with sleep disorders, specifically targeting Universiti Sains Malaysia students' sleep habits during university. It investigates whether light fundamentals affect psychological and scientific health aspects. A review of literature investigates appropriate artificial lighting for treating sleep disorders, with a focus on explaining the circadian rhythm and applying the right spectrum, offering important information. The researcher's final argument asserts that the quality of sleep can be enhanced by proper lighting design, especially for those suffering from insomnia. Adequate lighting, with proper lux levels, can improve sleep by establishing a suitable atmosphere, leading to improved overall health and well-being.

Introduction

Lighting, whether natural or artificial, is essential in architectural and interior design as it influences mood and enhances the overall look and feel of a space (Importance of Lighting – Anj 2019). Light, a form of energy emitted as radiation, is detected by the human eye within the visible spectrum from ultraviolet to infrared (Avci and Akbay 2021).

Circadian rhythms, which cycle every 24 hours, regulate body temperature, hormone levels, sleep quality, cognitive function, and other bodily functions. People spend about 90% of their time indoors, and poor artificial lighting, especially blue light, can disrupt circadian rhythms (Phillips et al. 2019).

Sleep is vital for survival, impacting the nervous, cardiovascular, endocrine, and immune systems (National Institute of Health). In Indonesia, about 70% of medical students experience inadequate sleep due to health problems, stress, and sleep conditions. Nighttime light can disturb sleep by affecting circadian rhythms and melatonin levels, leading to difficulties in initiating and maintaining sleep (Medical Journal Althea 2023).

Methods

This research utilises a review of existing literature to analyse how artificial lighting affects the circadian rhythm and sleep habits of students at Universiti Sains Malaysia. It examines and assesses important data from different research studies to comprehend the larger significance of artificial lighting. Furthermore, a study involving 20 students was carried out to collect information on their sleeping patterns and habits, evaluating their knowledge of artificial lightning's role in disrupting sleep. The research goal is to find suitable night lighting fixtures through the assessment of current products and light sources detailed in scholarly articles. Findings from the research and questionnaire will help in recognizing the significance of selecting appropriate bedroom lighting to enhance the quality of sleep.

Literature review

Artificial lighting

Artificial lighting is necessary in areas that cannot access or do not have natural light. It is the second-highest consumer of energy following air conditioning (Natsir, Jamala, and Kusno 2021). Electric lighting in buildings has various functions: setting the mood, emphasising areas and items, aiding in task completion, and displaying decorations (Natsir, Jamala, and Kusno 2021). Light plays a significant role in controlling sleep through the body's 24-hour biological clock, essential for regulating the circadian rhythm. The natural pattern of day and night signals our bodies when to wake up and when to sleep. Too much artificial light at night disturbs this cycle and makes sleep disorders worse (Walker et al. 2020).

Colour spectrum and temperature theory

Light affects sight, circadian rhythm, mood, and cognitive function. Recent research focuses on how the light spectrum and colour temperature (CCT) impact cognitive functions (Juan and Chen 2022). Higher CCTs are perceived as cooler shades, with warmer hues associated with lower Kelvin values and cooler hues with higher ones (Commercial LED Lights 2021). Red light enhances sleep quality and melatonin production. Warm yellow and orange lights minimally affect the circadian cycle, making them favourable for nighttime use, as they enhance melatonin production compared to cooler blue light (Light 2023).

Table 1. Shows the colour spectrum and temperature impact through visual and psychologic

Type	Measurement (K)	Visual effect	Psychological impact	Location/Space
Warm	less than 4000K	Warm glow (yellowish) or red colour.	It induces warmth and comfort, promoting relaxation	Bedroom, locations calming ambiance
Neutral	Within 4000K - 5000K range	Closely mimics sunlight, offering clear and even brightness.	Fosters balance, concentration, and alertness.	Educational, and colour-critical settings.
(moderate)	Above 5000K	Boosts wakefulness, focus, and efficiency.	Enhances wakefulness, focus, and efficiency,	Retails, hospitals, areas require focused attention.

Results and discussion

The research method in this paper consists of two parts: initially, examining existing studies on the effects of artificial lighting on the human circadian system, especially sleep disorders among students. The review discusses artificial lighting from architectural, medical, and recent technology. Next, information about artificial lighting requirements is organised in tables to determine appropriate light options for individuals suffering from sleep disorders, particularly insomnia.

Table 2. Papers analysing the architectural aspect of artificial light that influence the sleep condition or pattern

Year	Methodology		
	Description of the case study	**Discussion of lighting on circadian rhythm**	**Effect of artificial lighting on sleep pattern**
2021	Good Places to Live and Sleep Well: A Literature Review about the Role of Architecture in Determining Non-Visual Effects of Light	Connection between lighting and architectural design by providing a concise historical summary of the evolution of lighting techniques.	The strong link between the various impacts of light on individuals' health and happiness.
2021	The Role of Artificial Lighting in Architectural Design: A Literature Review	Artificial lighting is crucial for defining areas, enhancing surroundings, and increasing employees' efficiency.	Enhance the mood and functionality of a space.
2020	Circadian rhythm disruption and mental health	Aims how disrupting circadian rhythms through human night shift studies impacts human's mood	Mental health patients often experience inconsistent sleep patterns, which can lead to sleep disorders such (insomnia).
2019	Several biological benefits of the low colour temperature light emitting diodes (LED) based on a normal indoor lighting source	Showed that the suggested warm colour temperature (1900K) light could offer numerous important advantages in people's everyday lives.	Artificial light source with a (1900K) considered a "harmonious light" enhances the production of melatonin, leading to better sleep quality.
2021	OLED Lighting and Human Circadian System: A Review	Examines artificial lighting sources, with a specific emphasis on OLED lighting.	Sleep pattern can be improved because of light and technologies considering the impact on the user's circadian system and other factors
2019	Effects of light on human circadian rhythms, sleep and mood	This article examines what we currently know about how light impacts circadian rhythms, sleep, and mood.	Light has non-visual effects on circadian rhythms, sleep and emotion. Inappropriate timing can disturb natural body clocks and sleep patterns

Table 3. Analysing on current product that are suitable for sleep disorder

Type	Brand	Properties			
		Illuminance (lm)	**Colour spectrum**	**Temperature (K)**	**Voltage (V/W)**
Compact fluorescent light (CFL)	Osram	-	Warm	3200	120 / 277
			Cool	5600	
	Philip	1380	Warm	2700	20-240
	Panasonic	1180	Cool Daylight	6500	20 W
Incandescent	Osram	-	Cool	623.15	6.0
	Philips	-	Extra Warm White	2700	220-240
	Tungsten	1040	Warm	2900	10.8
LED	Philips	111	Cool	6500	220 – 240
	Ikea (Solhetta)	-	Neutral	4000	60 W
OLED	Osram	13	Warm white	2900	3.7
	Philips	120	Warm	3250	14.3

Table 4. Tables below shows the demography of the 25 students

Age (year)		**Gender**	**Occupation**	
Under 18	-	Female 18 (72%)	Student full time	15 (60%)
18-24	7 (28%)		Student and employed part-time	7(28%)
25-34	17(68%)		Student and Self-employed	

Age (year)		Gender	Occupation
35 and Above	1(4%)	Male 7 (28%)	(own small business) 3(12%)

Observation through conducting a questionnaire from google form 25 respondents' data be taken. A total of 72% (18) were females and 28% (7) were males according to their demographics. Students under 18 years of age were not recorded while the largest number of those aged 25-34 years were 28% (17 people), while the second 18–24-year-old recorded 7 (28%). A person who represents 4% is a student aged 35 and above. Demographics of their status regarding the students' jobs, it was recorded that the majority were full-time students, which was 60% (15 people out of 25 respondents). It was recorded that 12% (7 students) had part-time jobs. And students who have their own business as many as 3 people which is 12%.

Table 5. Analysing among 25 students about lighting preferences in respondents' room or house

Hours (per day) under artificial light		Checklist			
		Brightness		Colour temp	
4-6 hours	7 (28%)	Very dim	2 (8%)	Warm (yellowish)	11 (44%)
7-9 hours	13 (52%)	Dim	5 (20%)		
		Moderate	20 (80%)	Neutral (white)	21 (84%)
10 hours or more	5(20%)	Bright	10 (40%)		
		Very bright	2 (8%)	Cool (bluish)	-

Based on the collected data, most participants spent the longest duration under artificial light for 7-9 hours, with 13 students (52%) reporting this. 7 participants (28%) spent 4-6 hours, while 5 participants (20%) spent 10 hours or more. The "moderate" lighting option was chosen by 80% or 20 students as the most popular choice. 10 students (40%) preferred "Strong" lighting, 2 students (8%) preferred "Extremely bright," 5 students (20%) preferred "Low," and two (8%) preferred "Extremely low." 21 students (84%) favoured "Neutral" (white) as their preferred colour temperature, and eleven individuals (44%) chose "Warm" (yellowish). No students selected "Cool" (bluish) colour temperature.

Table 6. Analysing among 25 students of Universiti Sains Malaysia about the sleep routine

Average hours of sleep		Checklist			
		Trouble falling asleep		Feel when wake up in the morning	
4-5 hours	8 (32%)	Never	2 (8%)	Very rested	1 (4%)
6-7 hours	9(36%)	Rarely	6 (24%)	Somewhat rested	4 (16%)
8-9 hours	8(32%)	Sometimes	12 (48%)	Neutral	8 (32%)
		Often	5 (20%)	Somewhat tired	11 (44%)
				Very tired	1 (4%)

Information regarding their sleep habits can be identified from the table provided. The largest number of students (36%) reported sleeping for 6-7 hours, the highest total in the survey. In the meantime, 8 students (32%) each had an average of 4-5 hours and 8-9 hours of sleep. According to the data, 2 students (8%) have never had sleep issues, 6 students (24%) rarely face them, while 12 students (48%) experience them frequently, and only 5 students (20%) always have sleep problems. Furthermore, when it came to how they felt upon waking up in the morning, only one student (4%) felt extremely energetic, four students (16%) felt fairly energetic, eight students (32%) felt indifferent, eleven students (44%) were somewhat tired, and one student (4%) felt extremely tired.

Discussion of research papers

Case study 1: Architectural aspect

Case study 1 examines how daylighting principles have evolved over different historical periods and how they have impacted architectural choices. It highlights the importance of considering and prompting more research into

how they influence non-visual elements like circadian rhythms (Bellia and Fragliasso 2021).

Case study 2 examines how artificial lighting improves the visual attractiveness and usability of architectural spaces. It analyses different lighting fixtures and how they are incorporated into design standards. The study highlights the important role of artificial lighting in defining spatial aesthetics and establishing desired atmospheres in constructed space(Sholanke, Fadesere, and Elendu 2021).

Limitation

The research papers focus more on highlighting the importance of window placement and openings in enabling natural light. On the other hand, although artificial lighting is mentioned in one paper, the main emphasis is on its ability to improve the indoor environment and its potential to disturb the human body's circadian rhythm.

Case study 2: Medical view

The article "Circadian Rhythm Disruption and Mental Health" highlights uncertainties regarding the causal relationship between circadian disturbances and mental illnesses. It suggests that disruptions in circadian rhythms may increase susceptibility to mood disorders, vice versa, or that both conditions may share similar physiological mechanisms. Sleep disturbances are recognized as a significant link between circadian disruption and mood disorders (Walker et al. 2020).

Studies emphasise light's profound impact on circadian rhythms, sleep quality, and mood regulation through neurotransmitters like serotonin. Sunlight helps regulate circadian rhythms and can alleviate sleep issues, especially in those with mental disorders. However, timing is critical; late-daylight exposure can disrupt nighttime sleep and reduce deep sleep (Blume, Garbazza, and Spitschan 2019).

Case study 3: Lighting source and circadian

The research on the "Biological Advantages of Low Colour Temperature LEDs in Indoor Lighting" investigated how different light sources (1900K, 3000K, 4000K, and 6600K) impact various biological processes such as melatonin levels. Findings suggest that the 1900K light source has a beneficial effect on human circadian rhythms and overall health. Just like a real sunset, 1900K light is known as "harmonious artificial light" because it boosts melatonin production, ultimately leading to better sleep. The elevated levels of red light showing potential medical uses for improving sleep (Lin et al. 2019).

Another subject explores OLED lighting, which emits less blue light than traditional LEDs. Research highlights OLEDs as environmentally friendly and health-conscious options, offering better visual comfort indoors compared to LEDs (Avci and Akbay 2021; Jo et al. 2021) OLED lighting's effects on sleep quality and the circadian system, suggesting OLEDs as a viable LED alternative due to their reduced blue light emission, which affects melanopsin in retinal ganglion cells. OLED technologies offer several benefits over conventional lighting, positively impacting circadian rhythms and the environment (Avci and Akbay 2021).

Limitation

The research is its emphasis on recognising lighting fixtures exclusively from brands that use OLED technologies, designed for residential use. Although OLED technology provides benefits like increased energy efficiency and diverse lighting choices, its elevated cost in comparison to alternative light sources could limit its availability among the mass market for household purposes.

Observation

Data from tables 5 and 6 shows that most students spend 7-9 hours daily under artificial lighting, with some exceeding 10 hours, indicating a preference for indoor environments. Medium room lighting is favoured by 80% (20 students), 20% (2 students) prefer soft lighting, 40% (10 students) choose very low lighting, and 8% (2 students) opt for very bright lighting. At home, students mainly use Incandescent bulbs (60%), LED lights (76%), and fluorescent lights (52%). Regarding colour temperature, 84% (21 out of 25) prefer neutral (white), 44% (11 students) favour warm (yellowish), and none prefer cool (bluish). On average, students sleep for 6-7 hours, with 32% (9 students) achieving this. However, 48% (12 students) face occasional sleep challenges, and 44% (11 students) feel somewhat fatigued.This may be because 56% stay up past midnight during the week, waking at 9-10 AM for school, and on weekends, 56% go to bed after midnight and wake up at 12-1 PM, while 24% wake up at 10-11 AM. Sleep deprivation affects 52% of students, impairing concentration,

mood, and productivity, with 32% reporting it consistently hinders their daily activities.

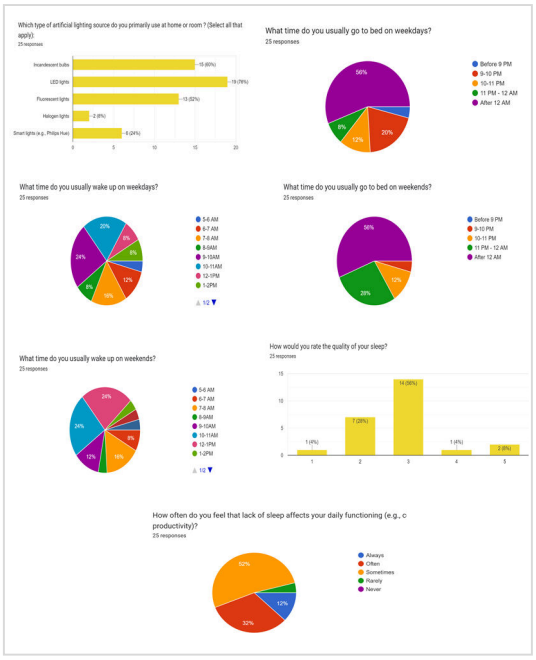

Figure 1. Type of artificial lighting sources primarily use at home or room
Source: Google form created by the researcherhttps://forms.gle/D2Gwb2EgSk7YMPvi8

Studies show OLED lighting is optimal for regulating circadian rhythms due to lower energy consumption and reduced blue light emission compared to traditional LEDs (Avci and Akbay 2021). OLEDs are preferred indoors for their visual comfort and health benefits (Jo et al. 2021). They are recommended for their warm colour temperature below 4000K or natural white between 4000K and 5000K. For better sleep, it's best to turn off lights completely; if needed, use very low, yellowish-red light to avoid disturbing circadian rhythms. Adjustable LED lights can also help maintain a regular sleep schedule. CFLs, which emit more blue light, are better for areas requiring higher visibility rather than spaces needing lower blue light exposure to protect melatonin production.

Conclusions

The research delves into the intricate relationship between lighting and human health from architectural, medical, and technological perspectives. Both natural and artificial lighting significantly impact perception, mood, and physiological functions. Light exposure regulates the body's natural rhythms, essential for bodily functions, but disturbances caused by artificial lighting can lead to health issues like sleep disorders. By reviewing literature and analysing case studies, the research underscores the importance of lighting in architectural design, highlighting daylighting principles and the effects of artificial lighting on indoor spaces. It examines how different light sources influence melatonin levels and health. The study also shows the potential of OLED lighting to mitigate the negative effects of artificial light on circadian rhythms. However, the availability and cost of OLED products could limit their widespread adoption. Overall, the study emphasises the need for appropriate lighting fixtures, especially in bedrooms, to improve sleep quality and overall health in modern indoor environments.

References

Avci, Ayse Nihan, and Saadet Akbay. 2021. "OLED Lighting and Human Circadian System: A Review." *Conference: AIC 14th Congress*, September.

Bellia, Laura, and Francesca Fragliasso. 2021. "Good Places to Live and Sleep Well: A Literature Review about the Role of Architecture in Determining Non-Visual Effects of Light." *International Journal of Environmental Research and Public Health* 18 (3): 1002. https://doi.org/10.3390/ijerph18031002.

Blume, Christine, Corrado Garbazza, and Manuel Spitschan. 2019. "Effects of Light on Human Circadian Rhythms, Sleep and Mood." *Somnologie* 23 (3): 147–56. https://doi.org/10.1007/s11818-019-00215-x.

Commercial LED Lights. (2021, March 2). *Lighting Colour Temperature Key Aspects You Need to Know*. Commercial LEDLights. Retrieved from https://commercialledlights.com/blog/lighting-articles/color-temperature/

Importance of Lighting – Anj. (2019). Anj.co.in. Retrieved from https://anj.co.in/idea-at-anj/importance-of-lighting/

Juan, Yi-Kai, and Yi Chen. 2022. "The Influence of Indoor Environmental Factors on Learning:

An Experiment Combining Physiological and Psychological Measurements." *Building and Environment* 221 (August):109299. https://doi.org/10.1016/j.buildenv.2022.109299.

Kusno, A. (2021). The Artificial Lighting Analysis of Study Rooms in Dormitories and Classrooms Islamic Boarding School Of Lil Banat Parepare. *EPI International Journal of Engineering*. Retrieved from https://www.academia.edu/90483903/The_Artificial_Lighting_Analysis_of_Study_Rooms_in_Dormitories_and_Classrooms_Islamic_Boarding_School_Of_Lil_Banat_Parepare

Light, Arvent. 2023. "The Psychology of Color Temperature in Lighting Design." Https://Medium.Com/@arventlightsys/the-Psychology-of-Color-Temperature-in-Lighting-Design-Eac179a2cf56. June 30, 2023.

Lin, Jiaqi, Xingwei Ding, Can Hong, Yulian Pang, Liming Chen, Quanwen Liu, Xu Zhang, Hongbo Xin, and Xiaolei Wang. 2019. "Several Biological Benefits of the Low Color Temperature Light-Emitting Diodes Based Normal Indoor Lighting Source." *Scientific Reports* 9 (1): 7560. https://doi.org/10.1038/s41598-019-43864-6.

National Institute of Neurological Disorders and Stroke. Brain basics: understanding sleep. National Institute of Health [Website] 2022 [cited 2023 Jan 02]. Retrieved from https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-understanding-sleep

Natsir, Nimah, Nurul Jamala, and Asniawaty Kusno. 2021. "The Artificial Lighting Analysis of Study Rooms in Dormitories and Classrooms Islamic Boarding School of Lil Banat Parepare." *EPI International Journal of Engineering* 4 (1): 87–98. https://doi.org/10.25042/epi-ije.022021.12.

Olajiga, O. K., Ani, E. C., Sikhakane, Z. Q., & Olatunde, T. M. (2024). A COMPREHENSIVE REVIEW OF ENERGY-EFFICIENT LIGHTING TECHNOLOGIES AND TRENDS. *Engineering Science & Technology Journal*, *5*(3), 1097–1111. Retrieved from A COMPREHENSIVE REVIEW OF ENERGY-EFFICIENT LIGHTING TECHNOLOGIES AND TRENDS

Sholanke, Anthony, Oladimeji Fadesere, and Daniel Elendu. 2021. "The Role of Artificial Lighting in Architectural Design: A Literature Review." *IOP Conference Series: Earth and Environmental Science* 665 (1): 012008. https://doi.org/10.1088/1755-1315/665/1/012008.

The relevance of daylight for humans. (2020). *Biochemical Pharmacology*, 114304. Retrieved from https://doi.org/10.1016/j.bcp.2020.114304

Vony Yurike, Bernardus Realino Harjanto, Nelly Tina Widjaja, & Veronika Maria Sidharta. (2024). Association between Lamp Light During Sleep and Sleep Quality in Medical Students. *Althea Medical Journal*, *11*(1), 45–49. Retrieved from https://doi.org/10.15850/amj.v11n1.3170

Walker, William H., James C. Walton, A. Courtney DeVries, and Randy J. Nelson. 2020. "Circadian Rhythm Disruption and Mental Health." *Translational Psychiatry* 10 (1): 28. https://doi.org/10.1038/s41398-020-0694-0.

Wang, T., Shao, R., Wang, Y., Li, J., & Hao, L. (2024). Impacts of Static Lighting in Confined Spaces on the Circadian Parameters, Alertness, Performance and Well-Being. *Buildings*, *14*(4), 1115–1115. Retrieved from https://doi.org/10.3390/buildings14041115

What Colour Light Helps You Sleep? (2023, May 25). Sleep Foundation. Retrieved from https://www.sleepfoundation.org/bedroom-environment/what-color-light-helps-you-sleep#references-80848

Zaky, A., Ova Candra Dewi, Widyarko Widyarko, & Coriesta Dian Sulistiani. (2023). Daylight and Artificial Lighting Integration In Achieving Lighting Uniformity In Educational Building. *Journal of Architectural Research and Design Studies*, *7*(1). Retrieved from https://doi.org/10.20885/jars.vol7.iss1.art5

Author(s) contribution

Nurfarah Eliyana Binti Rusdin contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Safial Aqbar Zakaria contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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