

A STUDY ON ILLUMINATION LEVELS IN THE BUILDING SERVICES ENGINEERING WORKSHOP AT POLITEKNIK SULTAN ABDUL HALIM MU'ADZAM SHAH

Nurul Nadia Syafika binti Mohd Aslan, Nur Ashikin binti Lakman*

Department of Civil Engineering, Politeknik Sultan Abdul Halim Mu'adzam Shah

*Corresponding author: nurashikin@polimas.edu.my

Abstract

Lighting is essential in building environments to ensure visibility, comfort, and effectiveness, particularly in educational settings. This study evaluates the lighting levels in the Building Services Engineering Workshop at Politeknik Sultan Abdul Halim Mu'adzam Shah, focusing on users' visual comfort. The main objectives were to assess students' perceptions of visual comfort and compare the measured illumination levels with the standards set by the Panduan Teknik Jabatan Kerja Raya (JKR). Illumination levels were measured in MPB1 workshop areas using a lux meter. A questionnaire survey was conducted over four weeks, involving 36 students who regularly use the workshops to gather data on their visual comfort. The results show that students reported high satisfaction with the current lighting, indicating a positive perception of visual comfort. Moreover, the measured illumination levels in all areas met the JKR standards, confirming the adequacy of the lighting system. These findings highlight the importance of maintaining proper lighting standards to ensure a conducive learning environment. The study concludes that the current lighting setup effectively supports the workshop's educational activities and provides a foundation for future improvements to optimise the environment further.

Keywords: Illumination levels, Lighting standards, Visual comfort.

INTRODUCTION

Lighting plays a pivotal role in creating conducive environments for work, learning, and overall well-being. Several studies highlight how important good lighting is for increasing comfort, performance, and productivity while reducing stress and weariness. According to studies, poor lighting impairs vision, impairs focus, and increases fatigue both mentally and physically (Duijnhoven *et al.*, 2019; Juslén *et al.*, 2005). All of these elements work together to emphasise how important it is to have well-designed lighting systems in a variety of settings. Both artificial and natural illumination in classrooms have a significant impact on students' wellbeing and academic achievement. Studies highlight how visual, cognitive, and behavioural skills are supported by natural sunshine and appropriate artificial illumination (Boyce *et al.*, 2003; Mott *et al.*, 2014). On the other hand, problems like glare, overly bright lighting, and inadequate daylighting can impair visual comfort and learning results, which emphasises the necessity of better classroom lighting system design (Michael *et al.*, 2017). Furthermore, subpar student achievement has been linked to insufficient environmental elements such as poor illumination, noise, and air quality (Baeza *et al.*, 2020). These observations highlight how important it is to solve lighting-related issues in order to design spaces that support wellbeing and productivity.

Numerous gaps are evident from the review of previous research. The effects of illumination in offices and classrooms have been the subject of much research, while specialised learning spaces such as technical training environments or workshops have received less attention. There aren't many researches specifically on illumination levels in Building Services Engineering workshops, where accuracy and concentration are crucial. Additionally, there has been a lack of exploration into

integrating users' visual comfort into the evaluation of lighting conditions, particularly in educational settings that involve hands-on activities. This study contributes to the field by focusing on evaluating lighting levels in the Building Services Engineering Workshop at Politeknik Sultan Abdul Halim Mu'adzam Shah. This study offers a more thorough understanding of lighting sufficiency in technical educational settings by combining quantitative lighting measures with qualitative evaluations of users' visual comfort. This study hopes to close current research gaps, offer suggestions for better lighting design in comparable learning environments, and improve the performance and learning experience of students receiving practical technical training.

LITERATURE REVIEW

In classroom settings, lighting has a significant impact on students' learning and development. Its important significance in improving cognitive and emotional development was underlined by Hartstein *et al.* (2010), who also pointed out that learning outcomes might be positively impacted by well-designed lighting systems. In a similar vein, Custers *et al.* (2010) noted that illumination has a direct impact on motivation, emotions, and cognitive function, fostering an atmosphere that promotes engagement and well-being. Additionally, Singh *et al.* (2020) determined the ideal brightness levels, indicating that lighting with 250–500 lux is especially beneficial for academic progress. Despite the acknowledged significance of lighting, Mott *et al.* (2014) urged more thorough investigation into the several physical elements of classroom settings, including lighting, noise, plants, and air quality, in order to better understand how they collectively affect kids' performance and wellbeing. According to Teplá *et al.* (2014), mood lighting can have a favourable impact on behaviour and emotional states, making it a useful addition to classroom design that promotes both cognitive and emotional benefits. In learning environments, natural illumination is also essential. According to Shin *et al.* (2012), glare must be reduced to preserve visual comfort since poorly designed windows or classroom layouts can be uncomfortable and interfere with learning. Using student questionnaires and simulations, Kim *et al.* (2014) investigated daylight settings in classrooms and found that sufficient natural light enhances performance and satisfaction while also being in line with students' preferences. Fakhari *et al.* (2021) combined computer simulations and student surveys to create a thorough model for evaluating visual comfort. Their methodology assessed a number of variables, including perceived temperature, window view pleasure, glare, perceived brightness, and lighting homogeneity. This method provided insightful information about striking a balance between the technical and aesthetic aspects of lighting, especially in art spaces and other classrooms with high visual standards. The literature concludes by highlighting the complex effects of lighting on students' performance and well-being.

RESEARCH METHOD

Sampling

The study sample comprises students enrolled in the Diploma in Building Services Engineering program. According to Krejcie and Morgan's (1970) sample size determination table, the study sample consists of 36 students, based on the total population of 40 students from semesters three and five.

Data Collection Methods

Questionnaires are used as the research instrument in the approach used to accomplish the first study objective. Respondents have to complete every element of the questionnaire. The data collected was analyzed using SPSS software, with reliability measured through the Cronbach's Alpha coefficient. According to Eisingerich and Rubera (2010), a variable that includes several signs is deemed credible if its Cronbach's Alpha value is at least 0.70. The Cronbach's Alpha rating for this pilot study was 0.9, which indicates that the questionnaire has excellent reliability. There are two sections to the questionnaire. Three questions about gender, ethnicity, and semester are included in Section A, while 13 items addressing perception, comfort, and acceptance of visual comfort are included in Section B. These items were adapted from Amorim (2022). Responses ranged from 1 (strongly disagree) to 5 (strongly agree) on a five-point Likert scale.

A lux meter and laser distance meter were used to measure the illumination levels at the Building Services Engineering Workshop MPB1 in order to accomplish the second study objective. To ascertain whether the workspace is adequately illuminated, lighting levels must be measured. The following are the steps to measure the lighting levels:

- i. The room's length and width, as well as the height of the lighting above the work plane, are measured.
- ii. The room index is calculated to determine the number of measurement points in a specific work area, using the formula:

$$\text{Room Index} = \frac{L \times W}{H_m(L + W)}$$

Where:

- L = Room length (m)
- W = Room width (m)
- H_m = Height of lighting above the work plane (m)

Table 1 is referenced to determine the minimum number of measurement points required. These points represent the minimum standard necessary, as outlined in the Guidelines on Occupational Safety and Health for Lighting at the Workplace (2018).

Table 1. Minimum requirement number of measurement points

Room Index	Number of Measurement Points
Below 1	4
1 and below 2	9
2 and below 3	16
3 and above	25

A lux meter is used to measure the lighting levels in the middle of each square once a smaller grid has been created (Figure 1). The results indicate the even distribution of lighting. Additionally, the average value of these measurements represents the average illumination level for the work area. To assess adequacy, the average illumination level is compared with the recommended lighting levels.

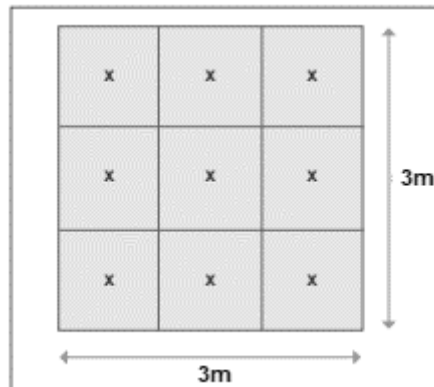


Figure 1. Lighting measurements in the center of a square divided equally

As part of the third research objective, the findings were compared with the Panduan Teknik JKR, which includes technical criteria for designing, material requirements, construction procedures, and other elements to ensure high standards in the development of infrastructure. According to Panduan Teknik JKR, Table 2 shows the suggested room illumination levels for various space types.

Table 2. Room illumination levels

General Building Areas	IES Standards Illumination Level	MS 1525 Recommendation	Panduan Teknik JKR
School			
Assembly hall general	special lighting	special lighting	special lighting
Platform and stage	300	300	200
Teaching spaces general	300	300	200
General where also used for further education	500	300	300
Chalkboard	500	300	300
Beedlework rooms	500	300	300
Art rooms			
Laboratories	500	300	300

Data Analysis Methods

Using SPSS software, this study uses descriptive statistical analysis to calculate the frequency, percentage and mean. The Panduan Teknik JKR, which acts as a benchmark for assessing whether the measured lighting satisfies the necessary criteria for different types of workspaces, is compared with the computed average illumination levels to guarantee the sufficiency of the lighting.

RESULTS AND DISCUSSION

Perceptions of Visual Comfort among Respondents

A total of 36 respondents from a variety of backgrounds took part in the poll. According to the results, 20 respondents (55.6%) are female and 16 respondents (44.4%) are male. Out of the 36 participants in this study, 31 (86.1%) are Malay, 3 (8.3%) are Indian, and 2 (5.6%) are of other ethnicities, according to the demographics of research participants. The composition of the study group, with fewer representatives from Indian and other ethnic groups, clearly shows a majority of Malay members. Only two semesters are recorded: Semester 3 and Semester 5. There were 16 responders in total during Semester 3, and 20 during Semester 5. Table 3 displays the respondents' profile.

Table 3. Profile of respondents

Category	Sub-category	Number of Respondents	Percentage (%)
Gender	Male	16	44.4
	Female	20	55.6
Ethnicity	Malay	31	86.1
	Indian	3	8.3
	Other	2	5.6
Semester	Semester 3	16	44.4
	Semester 5	20	55.6

Table 4 shows a comprehensive evaluation of a room's lighting and overall atmosphere, considering factors such as illumination color, brightness, uniform distribution, glare, and overall visual appeal. Every item is given a rating between 1 and 5, where 5 represents the maximum level of comfort and 1 represents the lowest. To illustrate the variation among respondents, the percentage distribution of answers is also provided. With particular strengths in comfort-related areas like appropriate light levels and a pleasing visual appearance, the room's visual environment is generally seen favourably, according to the mean scores for the individual elements and the overall mean score of 3.85.

Table 4. Visual Comfort Assessment of Room Lighting and Environment

No.	Item	1	2	3	4	5	Mean
1.	The color of the lighting in the room is warm.	7 (19%)	8 (22%)	8 (22%)	8 (22%)	5 (14%)	2.89
2.	The color of the surfaces seems natural, without distortion.	1 (3%)	9 (25%)	13 (36%)	13 (36%)	0 (0%)	4.06
3.	The room seems bright.	2 (6%)	1 (3%)	5 (14%)	16 (44%)	12 (33%)	3.97
4.	The light is distributed evenly in the room.	1 (3%)	5 (14%)	7 (19%)	9 (25%)	14 (39%)	3.83
5.		4	11	11	5	5	2.89

	There is imperceptible glare in the room caused by the lamps.	(11%)	(31%)	(31%)	(14%)	(14%)		
6.	Overall, the visual appearance of the room is very pleasant.	2	2	6	13	13	3.92	
		(6%)	(6%)	(17%)	(36%)	(36%)		
7.	The color of the lighting in the room is very comfortable.	0	4	5	11	16	4.08	4.04
		0%)	11%)	14%)	31%)	44%)		
8.	The appearance of the surfaces' colors is very comfortable.	0	2	7	13	14	4.08	
		(0%)	(6%)	(19%)	(36%)	(39%)		
9.	The amount of light in the room is very comfortable.	0	2	6	14	14	4.11	
		(0%)	(6%)	(17%)	(39%)	(39%)		
10.	The light distribution in the room is very comfortable.	0	1	8	15	12	4.06	
		(0%)	(3%)	(22%)	(42%)	(33%)		
11.	The lamp does not cause glare.	3	1	8	10	14	3.86	
		(8%)	(3%)	(22%)	(28%)	(39%)		
12.	Overall, the visual environment of the room is very comfortable.	0	2	6	17	11	4.03	
		(0%)	(6%)	(17%)	(47%)	(31%)		
13.	At this moment, the visual environment is acceptable.	0	0	4	16	16	4.33	4.33
		(0%)	(0%)	(11%)	(44%)	(44%)		
Overall Mean							3.85	

Lighting level measurement

The MPB1 area's room index, which is 0.99, is crucial for figuring out how many measurement points are needed for the lighting assessment. A room index below 1.0 requires at least four measurement points for a sufficient evaluation of lighting levels, according to the Department of Occupational Safety and Health (2018). However, the researcher decided to go well above the minimum criterion for this study by increasing the number of measurement points to 16. This choice was taken in order to improve the lighting evaluation's accuracy and dependability.

Data points collected throughout four weeks at various times of the day are shown in Table 5. The mean lux values for the morning lighting measures in Week 1 are 295 at 8 a.m., 279 at 9 a.m., and 335 at 10 a.m., for a weekly mean lux value of 303. The lux levels gradually increase as the morning progresses, indicating a rise in sunlight intensity due to the sun's position becoming higher in the sky. However, the values remained moderate, reflecting a combination of sunny and cloudy conditions. With mean lux levels of 266 at 8 a.m., 317 at 9 a.m., and 335 at 10 a.m., the morning lighting intensities in Week 2 show a modest increase over Week 1 with a weekly mean lux value of 306. The increase at 9 a.m. and 10 a.m. indicates better sunlight conditions as the day went on, whereas the lower lux at 8 a.m. indicates that the mornings started with some cloud cover or obstacles. Measurement peaks, such 394 lux at 9 a.m. and 436 lux at 10 a.m., show times of intense, direct sunshine, most likely brought on by clear skies in the latter morning hours. In Week 3, the lighting measurements further increase, with mean lux values of 306 at 8 a.m., 327 at 9 a.m., and 328 at 10 a.m., resulting in an overall weekly mean lux value of 320, the highest among all weeks. The consistently higher values reflect predominantly sunny conditions throughout the mornings. Peaks such as 406 lux at 10 a.m. indicate moments of intense, unobstructed sunlight. This trend indicates favorable weather with minimal cloud cover or obstructions, resulting in bright, stable lighting conditions across all three times. In Week 4, the lighting measurements decrease slightly compared to Week 3, with mean lux values of 285 at 8 a.m., 296 at 9 a.m., and 319 at 10 a.m., giving

an overall weekly mean lux value of 300. This decrease could indicate more overcast conditions or obstructions during this week, particularly in the earlier part of the morning. The lux levels increase progressively from 8 a.m. to 10 a.m., reflecting improved lighting as the morning progresses, due to the dispersal of clouds or changes in the sun's angle. Despite the slight dip, the lighting conditions remain consistent with moderate brightness, indicating a mix of sunny and cloudy periods.

Table 5. Morning lighting measurement data collected at different times across four weeks

Points	WEEK 1			WEEK 2			WEEK 3			WEEK 4		
	8am	9am	10am	8am	9am	10am	8am	9am	10am	8am	9am	10am
1	290	255	307	241	225	262	277	322	207	255	264	277
2	299	279	331	411	289	321	355	400	313	324	325	334
3	249	234	321	231	285	298	360	362	347	356	366	378
4	198	201	254	264	236	264	225	270	301	221	245	259
5	320	275	298	265	354	384	341	349	329	305	312	326
6	344	310	396	232	394	436	325	350	342	300	306	334
7	299	306	361	242	357	364	300	328	332	287	296	306
8	248	234	355	244	269	333	241	267	274	233	249	288
9	343	298	357	222	323	354	340	355	350	328	337	401
10	377	374	433	235	389	387	300	316	324	259	266	298
11	349	380	441	264	312	358	338	340	392	356	366	377
12	264	239	283	252	298	310	291	305	406	274	289	323
13	290	235	261	265	354	299	300	311	334	260	268	301
14	336	293	311	272	341	367	360	375	385	311	345	369
15	280	308	357	289	309	354	265	276	289	249	255	267
16	227	246	292	327	335	266	275	301	321	244	249	259
Mean (lux)	295	279	335	266	317	335	306	327	328	285	296	319
Overall Mean (lux)	303			306			320			300		
	307											

Table 6 provides detailed data on lighting measurements collected in the afternoon at three specific times (2 p.m., 3pm, and 4pm) across four consecutive weeks. In Week 1, the lighting measurements exhibit moderate intensity, with mean lux values of 265 at 2 p.m., 314 at 3 p.m. and 333 at 4 p.m. The overall weekly mean lux value is 304, which is relatively lower compared to subsequent weeks. The observed values show partly sunny or moderately overcast conditions during this week. The gradual increase in lighting intensity from 2 p.m. to 4 p.m. indicates that the sun's position and limited obstruction allowed for a slight rise in lux levels as the afternoon progressed. However, the absence of significant peaks indicates that cloud cover or environmental obstructions may have influenced the lighting measurements, preventing higher lux levels commonly seen in sunny conditions. In Week 2, the lighting measurements show a slight increase in intensity compared to Week 1, with mean lux values of 279 at 2 p.m., 320 at 3 p.m. and 325 at 4 p.m. The overall weekly mean lux value is 308, indicating moderately brighter conditions than the first week. The increase in lux levels suggests occasional sunny intervals mixed with cloud cover or light obstructions. However, the lower readings at 2 p.m. and the relatively stable levels throughout the

afternoon indicate consistent partial obstructions or overcast conditions that prevent a noticeable increase in brightness. This week's data reflects an environment where sunlight was present but frequently diffused or blocked. While in Week 3, lighting measurements exhibit a noticeable increase in intensity, with mean lux values of 382 at 2 p.m., 357 at 3 p.m. and 374 at 4 p.m. The overall weekly mean lux value rises to 371, marking a significant jump from the previous two weeks. The higher lux levels indicate predominantly sunny conditions with fewer obstructions during this week. Peaks like 575 lux at 2 p.m. and 587 lux at 4 p.m. further support the notion of bright, direct sunlight. While there are slight fluctuations in intensity across time periods, the overall higher values point to clearer skies and minimal interference from clouds or environmental obstructions. In Week 4, the lighting measurements reach their highest intensity levels, with mean lux values of 368 at 2 p.m., 409 at 3 p.m. and 350 at 4 p.m. The overall weekly mean lux value is 376, the highest among all four weeks. The consistently high lux values across the afternoon indicate predominantly clear and sunny conditions. Peaks such as 662 lux at 3 p.m. demonstrate moments of strong, unobstructed sunlight. Although there is a slight dip in intensity by 4 p.m., the overall pattern reflects favorable lighting conditions with minimal impact from clouds or obstructions. This week stands out as the brightest in the dataset, with optimal lighting conditions resulting from extended periods of direct sunlight.

Table 6. Afternoon lighting measurement data collected at different times across four weeks

Points	WEEK 1			WEEK 2			WEEK 3			WEEK 4		
	2pm	3pm	4pm	2pm	3pm	4pm	2pm	3pm	4pm	2pm	3pm	4pm
1	240	245	264	255	260	205	265	254	260	256	435	359
2	248	252	263	263	237	267	321	312	322	379	514	393
3	254	274	288	264	270	295	328	300	341	375	300	345
4	245	275	285	255	261	249	305	287	307	324	232	224
5	256	288	296	266	394	387	415	387	405	430	516	403
6	261	289	300	271	443	437	575	545	558	453	662	499
7	264	310	324	248	383	374	457	442	468	392	540	440
8	257	281	296	259	243	283	318	301	321	306	337	269
9	261	351	354	271	265	260	364	348	356	376	461	357
10	301	355	371	299	430	426	448	412	437	434	541	405
11	289	301	305	301	388	397	599	567	587	464	400	447
12	267	326	322	312	326	310	374	349	351	355	308	239
13	286	337	389	298	298	276	328	311	336	306	358	345
14	257	294	330	279	259	318	399	348	354	412	364	331
15	263	297	336	311	339	378	347	299	311	384	350	325
16	289	551	612	314	325	331	267	249	274	240	231	212
Mean (lux)	265	314	333	279	320	325	382	357	374	368	409	350
Overall Mean (lux)	304			308			371			376		
	340											

Comparison of Measured Lighting Levels with Panduan Teknik JKR

The overall daily average lighting level measured across the four weeks is 323 lux, which exceeds the Panduan Teknik JKR of 300 lux. This indicates that the lighting conditions observed

during the study meet the required standard. With an average that is consistently above the benchmark, the lighting levels can be considered adequate and compliant with the specified guidelines. This compliance ensures the environment is well-lit, supporting visual comfort and functionality during the observed periods.

CONCLUSION

The study focused on evaluating the interaction between natural and artificial lighting under varying environmental conditions and times of day. The overall daily average illuminance of 323 lux, which complies with the Panduan Teknik JKR of 300 lux, demonstrates that the lighting conditions effectively meet technical standards while ensuring visual comfort. The findings from the detailed visual comfort assessment, with an overall mean score of 3.85, support this compliance, highlighting satisfactory performance in aspects such as brightness, even light distribution, and minimal glare. The analysis also revealed that the combined lighting system is significantly influenced by external factors such as weather and obstructions, leading to variations in intensity. These findings underscore the importance of understanding the dynamic interaction between natural and artificial light to optimize lighting systems for both energy efficiency and user comfort. While the study provided an overview of lighting patterns through measurements and statistical analysis, it lacked precision in isolating the distinct contributions of natural and artificial lighting. Future research could explore methods to separately measure the effects of natural and artificial lighting in various environments. Simulation software and computational modeling could also be utilized to replicate various lighting scenarios and predict interactions under varying environmental conditions. These tools would allow researchers to develop lighting systems that comply with standards while improving energy efficiency and visual comfort in various settings. This integrated approach aims to optimize lighting systems, creating more adaptive and user-friendly environments.

ACKNOWLEDGEMENT

Sincere gratitude is extended to Mr. Ahmad Aizat bin Ramli, Architect at JKR Headquarters Malaysia, Kuala Lumpur, Mr. Azizul bin Ahmad, Mechanical Engineer at JKR Kedah and Mrs. Hjh Norainiah binti A. Rahman, Engineer at the Unit Pembangunan dan Senggaraan of POLIMAS, for their generous support and the opportunity to share and discuss the research conducted. Their valuable suggestions, feedback and continuous encouragement have greatly contributed to the enhancement of this study. Their time and guidance throughout this study process are deeply appreciated.

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