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Case Study on the Impact of Artificial Light on Lighting Performance Quality for Architecture Studios

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Abstract: A well-lit learning space is crucial to ensure the comfort of its occupants, especially for an architecture student who spends long hours in a studio to design, sketch, draw and build prototypes. This paper presents the results from a study conducted on the illuminance level of the architecture studios in the city campus of Universiti Tun Hussein Onn Malaysia (UTHM), Malaysia that were once laboratories. Measurements had been done using the Lux meter. Illuminance contours were generated using SigmaPlot and Dialux software for all the five rooms and compared with the requirements stipulated in the Malaysian Standard, Australia/New Zealand Standard and Illumination Engineering Society of North America (IESNA) standard for a room with similar function. A survey was also conducted among undergraduate architecture students who were using the studios daily to gauge their perception on the lighting condition and comfort level. The outcome of this study can be considered for future architecture studio lighting design to improve the students' learning experience.

Keywords: Artificial light, lighting performance quality, studios lighting

1. Introduction

The lighting in a learning space is important to ensure that learning can take place in a comfortable and adequately lit up environment. In an architecture studio, the learning activities that are carried out are mostly detail tasks that require high level of precision and accuracy such as designing, drawing, model making and so on. The quality of work really depends on the quality of lighting. A good lighting should have low glare; acceptable luminance ratios and white light; and leaves a positive impact on many aspects of a human functioning [1], [2]. A well-lit design studio, on the other hand, is beneficial to the learning progress, increases social interaction, and encourages creativity in design problem-solving [3]. Technically, the quality of lighting is defined as the standard of lighting installation which can fulfill human demands within defined constraints such as cost, energy consumption, and maintenance requirement [3].

When the lighting is poor, it causes visual discomfort and impairments that could eventually lead to low level of concentration and motivation to learn in the studios [4]. A common lighting issue in a student learning space is the existence of an inefficient and unnecessary form of fluorescent lighting [1]. Inefficient fluorescent lighting often leads to headaches and impaired visual performance [5], [6]. Unnecessary lighting, which can also be interpreted as excessive lighting, causes glare.

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This paper intends to discuss a study that has been conducted to identify the artificial lighting performance in terms of its brightness and illuminance in an architecture studio. Illuminance describes the light distribution, the beam direction, the color quality, and the glare limitation of a lighting installation [7]. In the context of this study, the illuminance for the selected architecture studios was measured using Lux Meter. The selected architecture studios are located at the city campus of Universiti Tun Hussein Onn Malaysia (UTHM), Parit Raja, Batu Pahat, Johor.

2. Artificial Lighting

Artificial lighting is essential not only for indoor spaces such as offices, factories and stores, but also outdoor spaces such as a tennis court even when there is no activity at night. The selection of artificial lighting is not a straightforward process and it demands for great attention on several important parameters. This includes the location of the light source, the type of lighting fixture, the intended distribution of light, and lastly the interaction of lights with the area and surface [8]. There are three type of artificial lighting, which are the general lighting, the task lighting and the accent lighting [9].

A lighting design takes the average illuminance as the benchmark to consider the level of illuminance and the number of lamps needed in a particular space or area. This benchmark is then recalibrated to suit the colour, space and layout arrangement of the area [10]. The same space can be considered as different area due to a difference in the colour, room function, source of lighting and also the arrangement of lighting in the space. All of these aforementioned aspects are related to the qualitative aspect of a lighting to create uniform illuminances [11].

In general, a good quality of lighting exists when a lighting system creates a comfortable condition for seeing to perform common activities such as reading, eating and walking. It also helps to create desirable interaction and communication, contribute to appropriate mood state (happiness, alertness, satisfaction and preference), promote a healthy and safe environment, avoid ill-effects, and contribute to the aesthetic judgment and appreciation of the space (assessments of the appearance of the lit space) [12], [13].

2.1 Fluorescent Lamp

Fluorescent lamp is a source of artificial light, created by an electrical discharge gas or vapour [14]. A parabolic fluorescent lamp is considered a general lighting or an ambient light, in which its main function is to act as a mood lighting to capture the soft curves of your face [15]. Table 1 shows the different size of common fluorescent tubes.

Table 1 - Fluorescent tubes size [9]

T Designation	Diameter (inches)	Diameter (mm)
T2	2 x 1/8” = 1/4”	7mm
T5	5 x 1/8” = 5/8”	16mm
T8	8 x 1/8” = 1”	26mm

2.2 Lighting Standard

In lighting systems, there are specific standards and regulation that should be referred to and taken into account even for a learning studio. According to Malaysian Standard (MS) 1525: 2014 “Code of Practice on Energy Efficiency [15] and use of Renewable Energy for Non- Residential Building” (second revision) for indoor lighting, the requirement depends on the function of the area and working environment. The Australian and New Zealand Standard (AS/NZS1680.2.3.2008: Interior Lighting and Workplace Lighting, Specific Application- Educational and Training Facilities), on the other hand, specifies the principles and recommendations for interior lighting that are primarily aimed at improving the lighting and comfort level for its occupants [16]. The Illuminating Engineering Society of North America Standard (IESNA) IESNA Lighting Handbook, ninth edition, could be the most important handbook to date. Table 2 illustrates the illuminance level requirement from the above-mentioned standards.

Table 2 - Illuminance level from the standard [10], [15], [16]

Standard	Standard Illuminance Level
Malaysian Standard (MS 1525)	300 – 400 Lux
Australia/ New Zealand Standard	600 Lux
IESNA Standard	750 Lux

3. Methodology

In this study, the illuminance level data of the selected architecture studios was collected using the Lux Meter. The illuminance levels were measured and recorded at each reading point with all artificial light left on. A laser distance meter was used to define a grid system prior to the measurement of each point [3]. Two software - SigmaPlot and DiaLux were used to analyse the measured data with the standard requirements to investigate its compliance to the recommended illuminance level [2].

The selected architecture studios are Studio 1 (three rooms) and Studio 2 (two rooms) as shown in Fig. 1 and Fig. 2, respectively. All rooms are located on the same floor since the building only has a single storey. As seen in Fig. 2, all rooms have roughly the same arrangement, whereby the windows and door are at one side of the room while the remaining three are only walls. Artificial light sources (fluorescent lights) are spaced equally across the ceiling except at Room 3 of Studio 1.

Other than the physical measurement, a survey was also conducted among the undergraduate students to investigate their personal comfort level when using the studios. A total of 30 students (20 students in Year 1, 15 in Year 2 and 15 in Year 3) had responded to the questionnaires distributed.

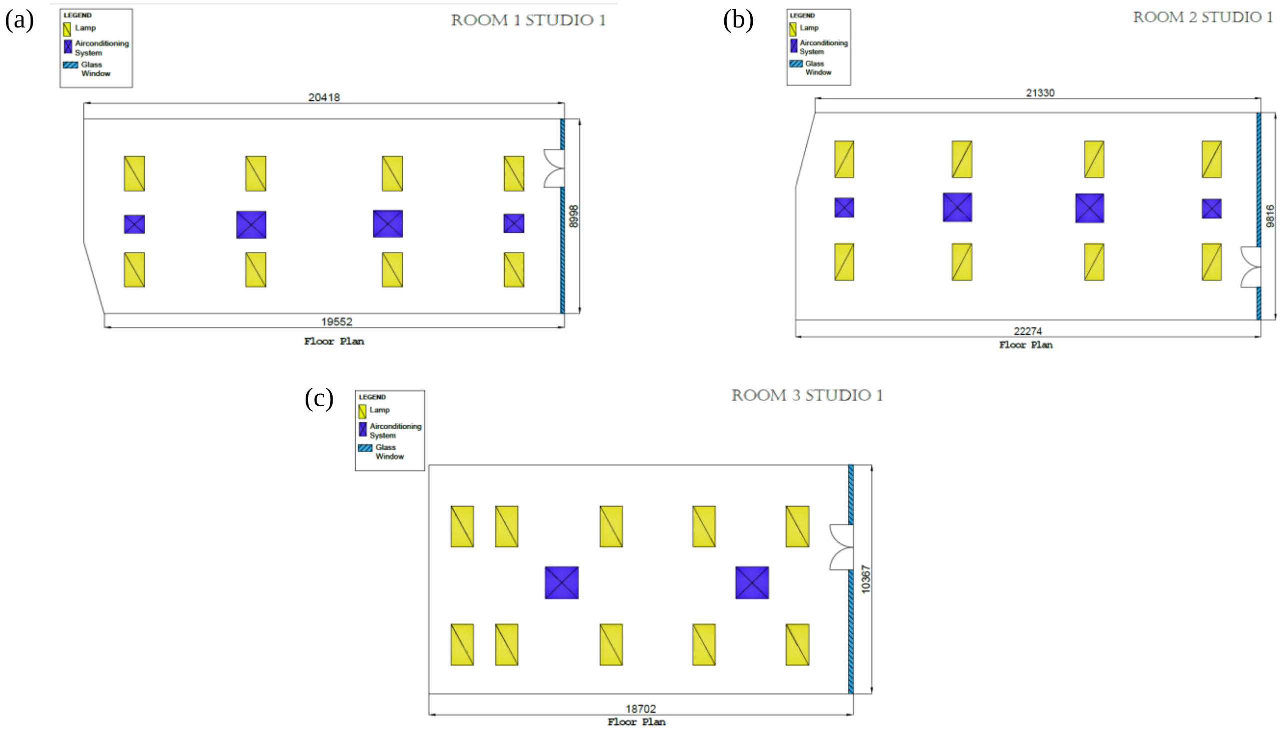

Fig. 1 - Floor plan for Studio 1: (a) Room 1; (b) Room 2; (c) Room 3

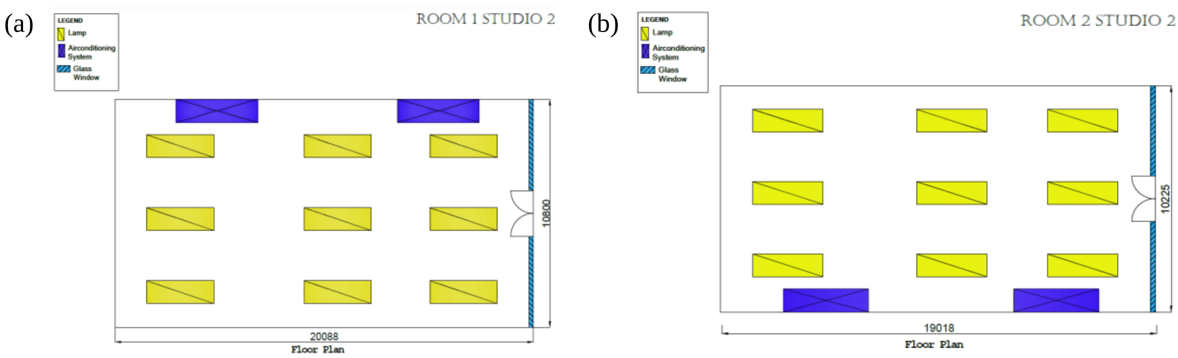

Fig. 2 - Floor plan for Studio 2: (a) Room 1; (b) Room 2

4. Result and Discussion

4.1 Measurement of Illuminance Level

The result from the Lux Meter reading was analysed using the SigmaPlot software and the compared with the standard requirements. Fig. 3 to Fig. 7 shows the contour of the illuminance level at each room. From all the results obtained, the level of illuminance has failed to meet the requirements stipulated in at least one of the three standards.

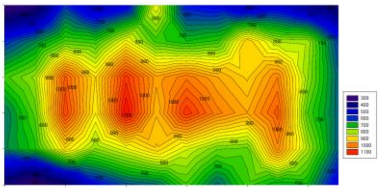

Fig. 3 - Illuminance contour for Studio 1: Room 1

Fig. 3 shows the illuminance contour in Room 1 (Studio 1). The contour showed that the illuminance value was over the recommended 300 Lux in the Malaysian standards, but some were below the requirements of the Australia/New Zealand standard (600 Lux) and IESNA standard (750 Lux). This was attributed to the ceiling height of the room and the arrangement of furniture. At the centre of the room, there were lesser furniture and thus, the artificial light that was directly on top could fall onto the Lux Meter. At other areas, the artificial light distribution had been blocked by furniture.

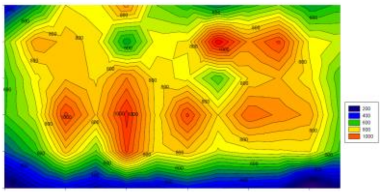

Fig. 4 - Illuminance contour for Studio 1: Room 2

Fig. 4 shows that the illuminance contour in Room 2 of the same studio. In this room, the illuminance level at the corners had met the Malaysian Standard (MS 1525) requirement while one corner had met the Australia/New Zealand requirement. The illuminance level at the centre of the room was higher and resembled the locations of the artificial lighting source. This is a clear illustration of the importance of artificial lighting source in determining the overall illuminance level of a room. In this room, the lighting distribution is still not well-distributed enough.

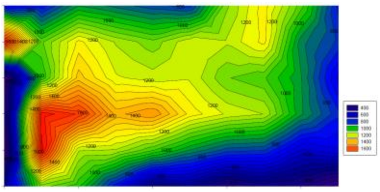

Fig. 5 - Illuminance contour for Studio 1: Room 3

Fig. 5 shows that the artificial lighting source seems to be the strongest at the front of the room. At the far end corner, the illuminance level was clearly lesser, but still above the recommended values in all three standards. The area with the highest illuminance level is in fact, the area with glass windows. The very high readings are from the natural light entering through the windows, as such cannot be considered as artificial lighting illuminance level.

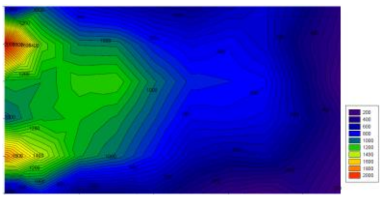

Fig. 6 - Illuminance contour for Studio 2: Room 1

Fig. 6 shows the illuminance contour for Room 1 at Studio 2. Similar to Room 3 at Studio 1, the area with windows is clearly more well-lit due to natural light entering. In fact, this room had recorded the highest illuminance level at 2000 Lux. Unfortunately, the opposite area is poorly lit even with artificial light. The dimmer area failed to meet the requirement of both Australia/New Zealand standard and the IESNA standard in most cases. The furthest corner had the lowest reading among all rooms at 200 Lux only. This depicted a poor distribution of illuminance level across the room, where one corner was so bright to the extent of glaring while another corner was very poorly lit.

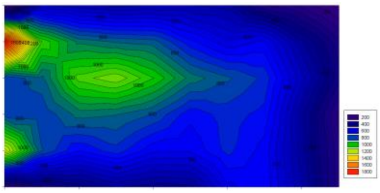

Fig. 7 - Illuminance contour for Studio 2: Room 2

Fig. 7 depicts the illuminance contour for Room 2 at Studio 2. This room undeniably has the poorest illuminance level among all five rooms. More than 50% of the room failed to meet the requirement of the IESNA level. About a third of the room had failed to meet the requirement of the Australia/New Zealand standard while a corner had only recorded 200 Lux. The high readings were caused by the natural light entering the room through the glass windows. The highest reading was 1800 Lux; this is way above the stipulated requirement and can even be considered glaring.

The results clearly showed that none of the rooms had fully complied to the requirements stipulated in the three standards. The major difference in readings, even for the same room, is caused by several factors. These include the orientation of the building; the orientation of the windows and door; the location of the light source; the arrangement of the furniture; and the location of the Lux meter when the measurement was done. The location of the room as well as its orientation greatly affects the amount of natural light entering the room, these are evident in Fig. 6 and Fig. 7. The actual condition of these room are shown in Fig. 8. The left photo showed that the room had become glaring due to excessive sunlight entering the room. The right photo, on the other hand, shows that the architecture studios are located at a single-storey building.

(a) (b)

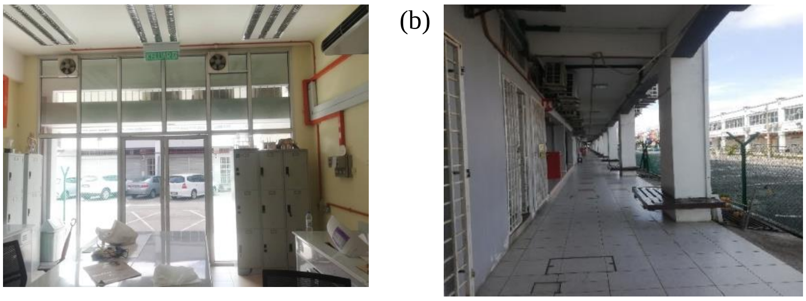

Fig. 8 – (a) Door and window of the room; (b) The hallway for ground floor level that architecture studios located

The illuminance level is also affected by the finishing and colour of the rooms, as shown in Fig. 9. This arrangement is the same across all rooms. Bright colour is able to reflect more lights and since there is no curtain provided as well, this could be the reason that all-natural lights have entered the room and spiked the illuminance level.

a b

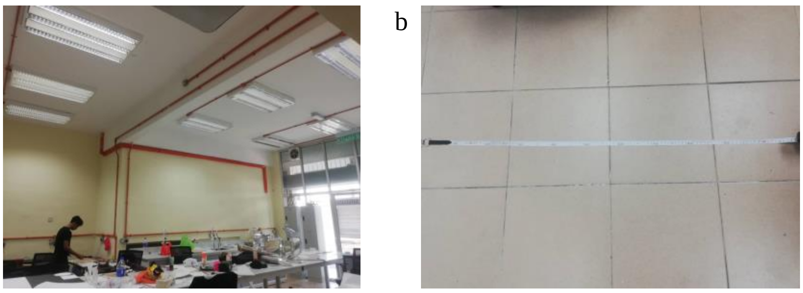

Fig. 9 - The colour of the: (a) wall; (b) floor of the studios

Before the architecture studios were established, the rooms were used as laboratories. The illuminance was high because the original room design was for a laboratory setup instead of a learning space. The original function of the room and the value of illuminance would have been compatible, but since the rooms have become architecture studios, the illuminance level is no longer suitable. To be more precise, the kind of learning activities common to an architecture student such as sketching, drawing and model building require a more comfortable illuminance level for long term usage.

4.2 Survey Forms

For the questionnaire survey, it has been administered online to the architecture students using the Google Form. The total response rate along with the proportion of gender are presented in Fig. 10.

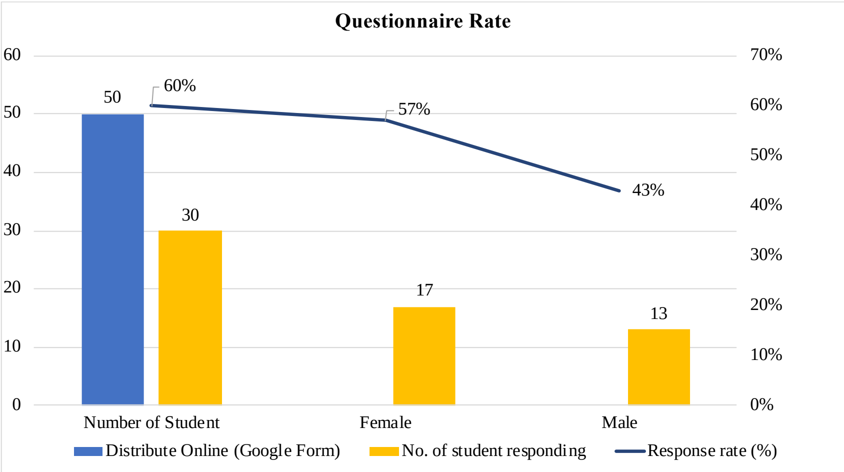

Fig. 10 - Total value of response rate

Table 3 - Students' response and visual health

	Number of questions	Yes	No	Total (%)
Q1	Status: Do you wear glasses or contact lens?	12 *40%*	18 *60%*	30 *100%*
Q2	Vision problem: Do you have any vision problem?	12 *40%*	18 *60%*	30 *100%*

Table 4 - Students' response on number of hours spent in the studios every day

	Number of questions	1 – 3 hours	4 – 6 hours	More than 6 hours	Total (%)
Q3	Hours spend: Normally, how many hours you would spend in the studios?	5 *17%*	14 *47%*	11 *37%*	30 *100%*

Initially, a total number of 50 students were selected to answer the survey. However, only 30 students had attempted the survey. It should be noted that the survey result is based on the feedback from the students who were actually using the studios on a daily basis. From Table 3 and Table 4, it can be seen that 60 % of the students did not wear glasses or contact lens. Close to 50 % of these students would spend four to six hours in the studios every day.

The students' perception on lighting level performance in the studios is shown in Fig. 11. Question 4 to 9 measured the respondents' perception on the lighting condition while Question 10 to 14 gauged their comfort level in the same lighting condition. The ratings are presented on a Likert scale from 1 (strongly disagree) to 5 (strongly agree).

Fig. 11 shows that most students had neither agreed nor disagreed to the statements presented in six questions (Q4 to Q6, Q9, Q13 and Q14) since the average index of the responses were between 3 and 4. This means that the students were indifferent to the amount of natural light entering the studios, the adequacy of lighting and its influence on their learning. However, the students seemed to have higher level of awareness on the influence of a good lighting and environment. Most agreed that a good level of lighting would help with their study (Q7), the colour of the wall would affect the quality of the lighting (Q8) and the importance of these two on their architectural works (Q10, Q11 and Q12).

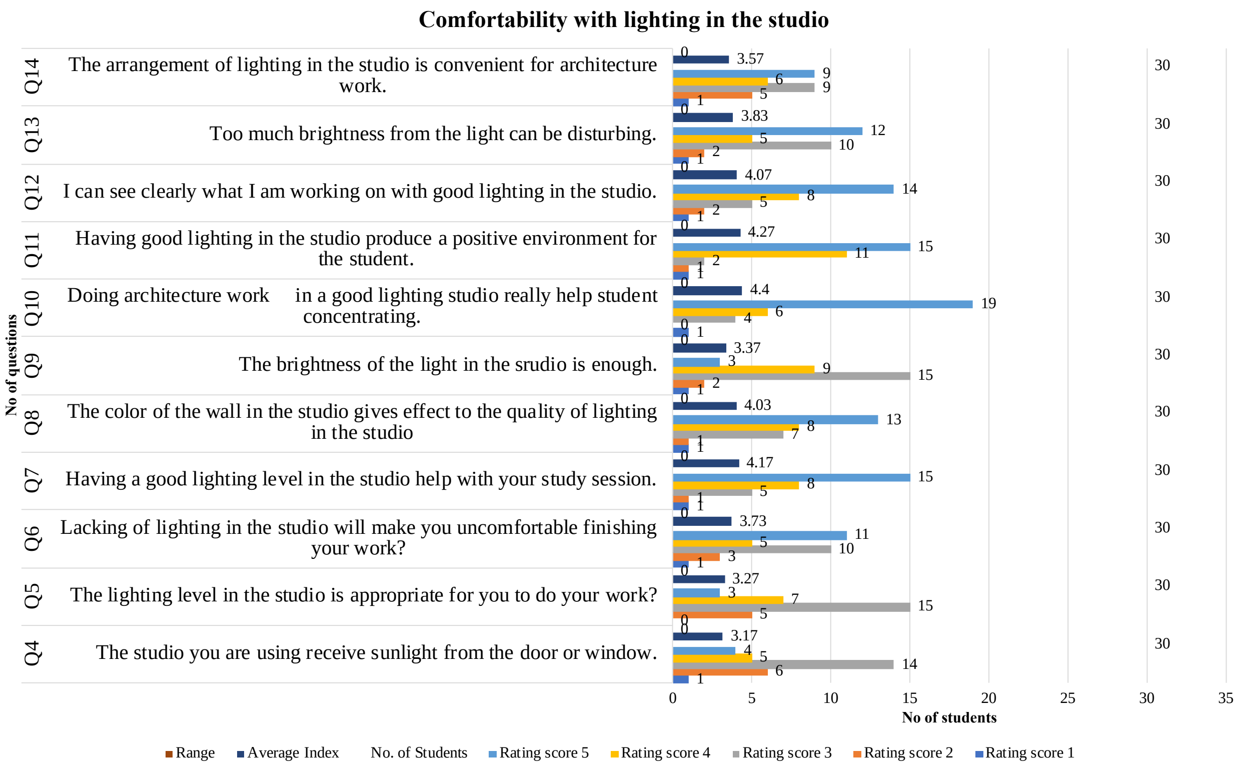

Fig. 11 - Students' response on the lighting condition and comfort level in the studios

Considering all responses, it can be said that the students did not feel the current condition had caused noticeable comfort or discomfort to their learning experience, but a good lighting and environment would definitely enhance their learning. Breaking down into greater detail, 11 of the students felt the lighting was good and convenient for their learning while 16 felt some form of improvement could be implemented such as changing out the old faulty light bulbs. Three students expressed that they would prefer natural light, but with the option to block out the glare with curtains.

5. Conclusions

This study was conducted to measure the illuminance level at the architecture studios of UTHM. The study concluded that all rooms had failed to fully comply to the illuminance level stipulated in the Malaysian standard, the Australia/New Zealand standard and the IESNA standard. The incompliance has been attributed to the change in the original room function from a laboratory setup to a learning space. A survey had been conducted to gauge the architecture students' perception on the lighting condition and comfort level. The result showed that the current condition has caused neither comfort or discomfort, but improvement could be done and are welcomed by the students.

Acknowledgment

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References

[1] Julian W. (2008). Lighting: Basic Concepts. University of Sydney

[2] Hamid A. A. A. (2010). A Study of Internal Lighting Comfortability at Lecture Room. Doctoral Dissertation, Universiti Malaysia Pahang

[3] Wasilah P. J. & Rachmawati M. (2013). Artificial lighting design at the lecture theatre of the faculty of engineering, Hasanuddin University. International Journal of Engineering Science and Innovative Technology, 2, 64-71

[4] Skarlatou A. (2010). Light Effects in the Design Process. PhD Dissertation, University College London

[5] Musa A. R., Abdullah N. A. G., Che-Ani A. I., Tawil N. M. & Tahir M. M. (2012). Indoor environmental quality for UKM architecture studio: An analysis on lighting performance. Procedia-Social and Behavioral Sciences, 60, 318-324

[6] Kralikova R., Piňosová M. & Hricová B. (2016). Lighting quality and its effects on productivity and human healts. International Journal of Interdisciplinary in Theory and Practice, 10, 8-12
[7] Kreider J. F. (2000). Handbook of Heating, Ventilation, and Air Conditioning. CRC press
[8] Ganslandt R. & Hofmann H. (1992). Handbook of Lighting Design. ERCO Edition
[9] Mathers M. (2010). The Basics of Efficient Lighting. National Framework for Energy Efficiency
[10] Illuminating Engineering Society of North America (2000). IESNA Lighting Handbook. IESNA Publication.
[11] Liberman J. (1991). Lighting Medicine of the Future. Bear and Company Publishing
[12] Allan H. (2017). Choosing the Right Photometer/Illuminance Meter. Institution of Lighting Professionals.
[13] Knez I. & Kers C. (2000). Effects of indoor lighting, gender, and age on mood and cognitive performance. Environment and Behavior, 32(6), 817-831
[14] Stein B. & Reynolds J. S. (2000). Mechanical and Electrical Equipment for Building. John Willey and Sons.
[15] MS1525 (2014). Code of Practice on Energy Efficiency and use of Renewable Energy for Non-Residential Building. Malaysia Standard
[16] AS/NZS 1680.2.3:2008 (2008). Interior and Workplace Lighting, Part 2.3: Specific Application-Educational and Training facilities. Standards Australia/Standards New Zealand