Illuminance Level Measurement at Lower Working Plane Height in Islamic Religious School

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Abstract: Islamic religious school is an institution that integrates Quran *hafazan* (memorization) in the curriculum. Between 2011 to 2017, estimated that 900 new Islamic religious schools were established in Malaysia due to high demands. Designing a classroom layout that receives sufficient daylight is important because it influences the students' task performance such as reading and writing. The standards recommend that any classrooms require an illuminance level between 300 lx to 500 lx when measured at working plane height between 800mm to 900mm, although the working plane height of *rehal* used for *hafazan* is between 250mm to 300mm. This study focused on the illuminance level measured at *rehal* working plane height for Arabic handwriting as a hafazan learning task in two selected standardised classrooms at Kolej Genius Insan. The students were required to rewrite the modified Balsam Alabdulkader-Leat (BAL) Arabic eye chart, where the students' Arabic handwriting performance were evaluated based on their word per minute (wpm) scores. Both classrooms' average illuminance level were 507 lx to 603 lx, which were too high based on standards and guidelines. The average Arabic handwriting scores for both classrooms were 9.4 and 12.6 wpm, which shows that the inefficient average illuminance level has caused the students' performance to be very low. It can be concluded that the existing standardised classroom layout design was not suitable for *hafazan* learning tasks at *rehal* working plane height. Thus, the classroom layout design for Islamic religious schools needed further studies, which implicated the unsatisfied built environment of the classrooms and the school education for Islamic religious schools in Malaysia.

Keywords: Arabic handwriting, Daylighting, Illuminance level, rehal, working plane

1. Introduction

As we know all education systems were designed to educate and prepare young minds for their future, and ultimately the workforce (Ismail, Bakar, & Mohamed, 2019). Thus, learning space design has been influenced by various factors such as governments' policies, educational systems and space requirements throughout the years. Around 1904, 'open-air design' concept was popularised in Europe, where the concept focused on the improvement of ventilation and natural daylighting in learning spaces (Châtelet et al., 2003). However, the concept received a major backlash due to the high intensity of daylight in the learning space that caused glare and visual discomfort to the students (Wu & Ng, 2003). Since then, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Illuminating Engineering Society of North America (IESNA) and Malaysian Standard 1525 (MS1525) were amongst some of the standards and guidelines that studied and suggested the acceptable illuminance level in learning spaces at 800mm to 900mm working plane height. However, Islamic religious schools in Malaysia commonly used a *rehal* with lower working plane height of 300mm from floor level.

Islamic religious schools in Malaysia have been increasing in demand since 1999, where 220 new institutions were established until 2011 (Bani, et al., 2014). The Islamic religious schools in Malaysia adapted the *Ulul Albab* curriculum that traditionally used a book rest or *rehal* with 300mm working plane height for *hafazan*, which was the height clearance for crossed-legged or squatting position based on Neufert and Metric handbook (Syaheeza & Husini, 2018). In fact, the Seljuq Dynasty has been using *rehal* for *hafazan* learning tasks such as reading and writing the Arabic language since the 10th century (Fuady, 2015). Thus, this study focused on the illuminance level measured at 300mm working plane height and its effect towards the students' *hafazan* learning task performance, which was measured based on the students' word per minute (wpm) score for Arabic language writing.

2. Problem Statement

Various standards and guidelines suggested that the acceptable illuminance level for any learning spaces should be between 300 lx to 500 lx. Most of the public schools in Malaysia had inadequate illuminance level in the classrooms, where only 25 percent of the selected public schools achieved the standards and guidelines recommended illuminance level between 300 lx to 500 lx (Mathalamuthu et al., 2018). Although, the research was based on the illuminance level measured at 900mm working plane height instead of a lower working plane commonly used for *hafazan* in Islamic religious schools. Different working plane height influenced the illuminance level measured, even though the window sill and head height was constant (Syaheeza et al., 2018).

Since most of the daylighting research were conducted in a non-religious schools that used table with 800mm to 900mm working plane height (Edwards & Torcellini, 2002; Heschong et al., 2002; Winterbottom & Wilkins, 2009; Samani & Samani, 2012; Mirrahimi et al., 2013; Sojoudi, 2014; Yacan, 2014; Barret, et al., 2015; Vi Le et al., 2016; Shishegar & Boubekri, 2016; Al-Ashwal & Hassan, 2018; Syaheeza et al., 2018), hence, recent daylighting studies still lack the references on the acceptable illuminance level in religious schools, which required specific tasks such as reading and writing Arabic language at lower working plane height. Hence, the increasing demand for Islamic religious schools in Malaysia (Bani, et al., 2014) showed a significant concern in the daylighting conditions in classrooms for *Ulul Albab* education.

3. Literature Review

The literature review which focused on the effects of illuminance level on the students' performance and behaviour in the classroom has been reviewed. Most of the relevant references which are relevant to illuminance level in learning spaces by standards and guidelines have been included.

Additionally, the historical background of Islamic religious schools and implementation of *Ulul Albab* education in Malaysia were also referred to in this literature review.

3.1 Daylighting Effect towards Students' Performance and Behaviour

Acceptable illuminance level recommended in standards and guidelines was based on the students' visual comfortability during any specific tasks that required a certain amount of light such as writing and reading (MS1525, 2014). Indoor lighting in general has influenced the occupants' desire and satisfaction to do specific work tasks (Elina, 2016). High daylight amount and intensity will create visual discomfort such as glare to the occupants, thus reducing the occupants' work performance (Arabi, et al., 2018). Table 1 shows the recommended illuminance level for learning spaces by various standards and guidelines.

Table 1. Standards and Guidelines on Illuminance Level

Standards and		Malaysia		Others		
Guidelines	OSHA	MS1525	JKR	Zumtobel	EFM	IESNA
General Teaching Area	300	300-500	300-500	300	215-430	300-500
Library		300-500	300			300

Malaysian standards and guidelines recommended the same illuminance level for learning spaces, which ranged between 300 lx to 500 lx. IESNA and Zumtobel lighting handbook also recommended the same illuminance level range, with exception of Philippines' Education Facilities Manual (EFM) that had recommended a lower range between 215 lx to 430 lx. Malaysian standards and guideline recommended illuminance level was referred as the benchmark for this study. Even though daylighting studies were commonly related to energy efficiency, however, sufficient daylight in classrooms is considered important to improve the students' learning outcome, performance and behaviour (Heschong et al., 2002; Ibrahim & Ahmad, 2013).

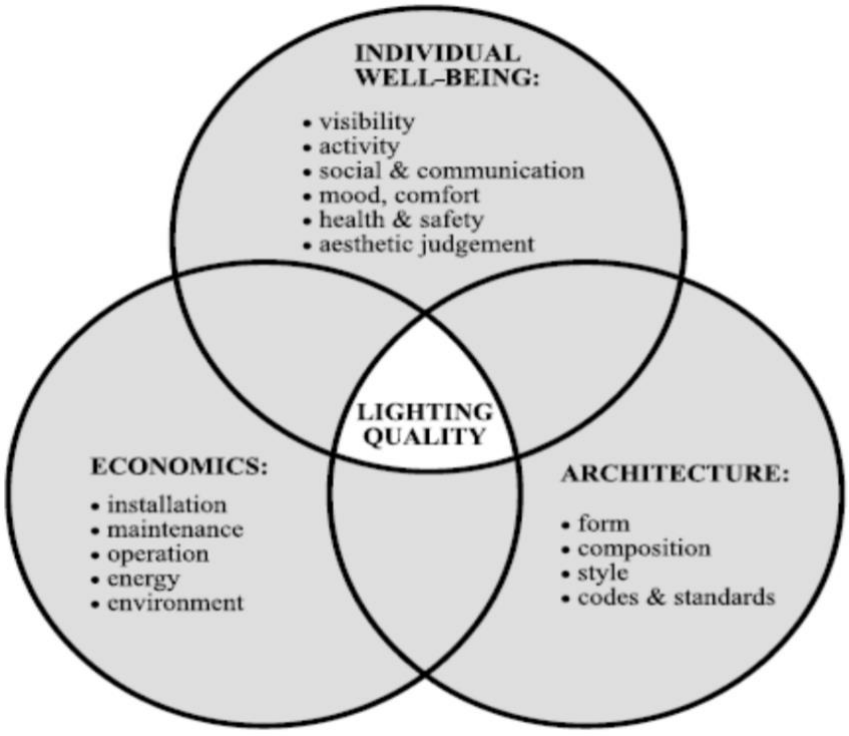

Fig. 1 Lighting quality components (Samani & Samani, 2012)

Fig. 1 shows the components of lighting quality, which consisted of individual well being, economics and architecture, where this study focused on the individual well being component that have influenced the students' performance and behaviour in the classroom. User behaviour can be defined as human's actions during a complex interactions with external and internal factors such as emotions, habits, routines, moral conduct, contextual conditions, attitude, values, beliefs, culture, norms and constraints (Gill et al., 2010; Lourenco, 2019). In brief, lighting quality can be seen as a contextual condition factor that influenced human behaviour, where a good lighting quality can improve:

i. Visibility for efficient daily routine activities

ii. Comfort and good mood for positive emotions

iii. Social and communication condition for a better attitude

iv. Health and safety for habits and norms

In the past, most classrooms with efficient illuminance level significantly have affected the students' performance, which was due to the efficient daylighting strategies of the classroom (Vi Le et al., 2016). Students in a sufficiently daylit classroom learnt to read 26% faster compared to ones in an insufficiently daylit classroom (Heschong, 1999), which proved that insufficient or very low daylighting in classrooms poorly developed the students' performance (Gilavand et al., 2016). This can be explained that light efficiency influenced the students' physiology, which also influenced the students' learning ability (Begemann et al., 1997; Edward & Torcellini, 2002). However, a very high amount of daylight also had a negative impact on the students' performance due to glare and other visual discomfort (Plymton et al., 2000). In general, various researches proved that efficient daylight has improved the students' psychology, health, cognitive skills and performance, social skills, alertness, attention span, sleep quality, physical activities and subjunctive moods (Samani & Samani, 2012; Yacan, 2014; Shishegar & Boubekri, 2016; Zumtobel, 2018). However, the daylighting studies were commonly conducted in green schools due to the efficient daylighting strategies implemented in the classrooms (Erwine & Heschong, 2002; Issa, et al., 2012; Demir & Konan, 2013).

Syaheeza & Husini (2018) suggested that natural daylighting was also important in Islamic religious schools for *hafazan* learning tasks such as reading and writing Arabic language. Further study suggested that illuminance level within the recommended range of 300 lx to 500 lx or higher reduced the students' Arabic handwriting word per minute (wpm) score (Syaheeza, et al., 2018). A study in classrooms that were designed specifically for *hafazan* education had average illuminance level up to 1600 lx, which was not suitable for any learning tasks activities (Arabi et al., 2018). This shows that daylighting research in Islamic religious schools requires further studies.

3.2 Islamic Religious Education in Malaysia

Psychologists defined *hafazan* as a memorisation process for long memory retention, which involved recitation of the Quran (Fadhilah & Ashaari, 2015). *Sama'i* (listen) and *Jama'* (recite together) were commonly used as learning and teaching methods for *hafazan* during the Seljuq Dynsaty (Fuady, 2015). Other methods identified were *Wahdah* (read one by one), *Kitabah* or *Tahriri* (write), *Syafawi* (recite) and *Tasmi'* (check the memorisation) (Ikhwanuddin & Hashim, 2014; Hashim, 2015). *Madrasah* in Malaysia commonly used the *Tasmi'* method, where the teacher or tutor checked the students' recitation or writings of the Quranic verses individually (Abdullah, et al., 2003).

The first prime minister in Malaysia, Tunku Abdul Rahman Putra Al-Haj in 1966 established the *Tahfiz* Institution based on the idea coined by Sheikh al-Azhar Sheikh Mahmud Syaltut. *Tahfiz* schools were defined as schools with a government standardised curriculum that inserted Islamic religious studies

known as *Ulul Albab* education. Since then, the Islamic religious schools have increased from 58 to 278 institutions between 1999 to 2011, which proved that there was an increasing demand in Malaysia (Bani, et al., 2014). To date, public schools were also required to implement *Ulul Albab* education based on the General Circular by the Ministry of Education Malaysia (MoEM) in 2016.

Based on what has been defined by Asimov (1999), *madrasah* implemented both secular education and religious oriented education. *Madrasah* as a clear separation between religious ritual spaces and religious study spaces was established during the Seljuq Dynasty due to political interventions (Fuady, 2015). Quoting Michael Stanton by Fuady, *madrasah* during the Seljuq Dynasty used a small (*rehal*) table in the classrooms, where the working plane height was 300mm. This height was suitable for a crossed-legged or squatting position based on Neufert and Metric handbook, which was adapted by most of Islamic religious schools in Malaysia (Syaheeza & Husini, 2018).

4. Methodology

This study consisted of two methods, which were illuminance level field measurement and students' Arabic handwriting performance. The selected respondents were secondary school students aged 13 and 14 years old, where most of the Islamic religious schools catered for secondary school students, while overcoming the students' limitations on reading skills (Vi Le, et al., 2016). The two classrooms selected were from Kolej Genius Insan, Nilai, Malaysia. The school inserted *Ulul Albab* education as a part of the curriculum. The classrooms' floor area was 59.5m2, which can be occupied by 24 students. The number of students per classroom was based on Guidelines and Regulations for Building Planning (GRBP), where 2.5m2 floor area per student was the minimum requirement as shown in Fig. 2.

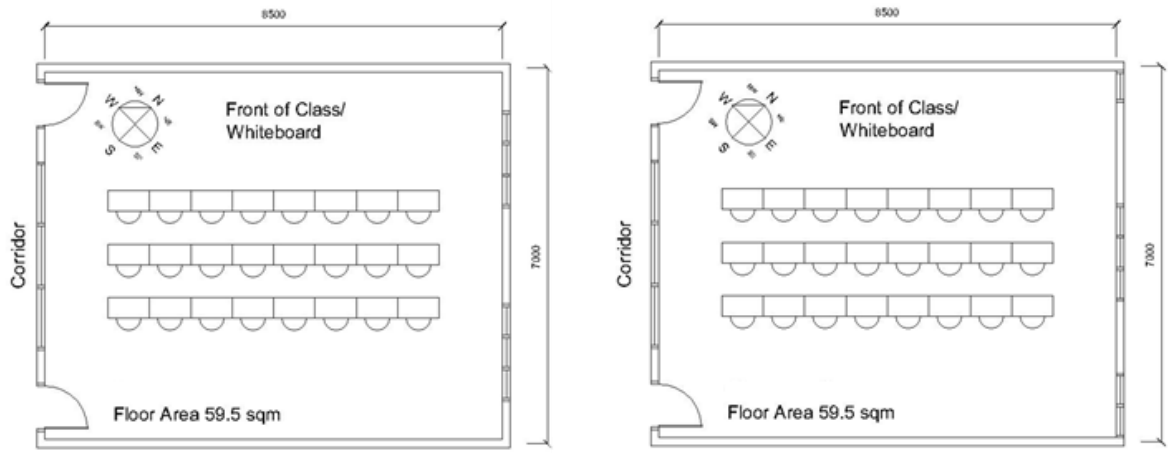

Fig. 2 Classroom One (left) and Two (right) Floor Plan

The classrooms selected had approximately 15% of Window-to-Floor Ratio (WFR), which were lower than the recommended standard in Uniform Building by Law (UBbL) Malaysia and MS1525 as shown in Fig. 3. In order to avoid any immediate daylight penetration obstacle through the window, the classrooms selected were located at the second floor. Illuminance point measurement data loggers were placed 2m away from the walls with windows to avoid direct daylight penetration on the working plane (Mathlamuthu & Ibrahim, 2014; Syaheeza, et al., 2018).

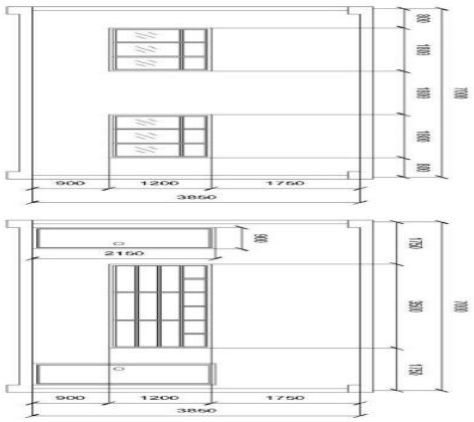

Fig. 3 Classroom One and Two Side Elevation

4.1 Illuminance Level Field Measurement

Luminance spot measurement method was used for this study to measure the average illuminance level for each classroom. The lux meters were arranged in a 1m x 1m grid of the floor area at 300mm working plane height (Theodorson, 2009; Zomorodian, et al., 2016) as shown in Fig. 4. This experiment was conducted between February to April, where the sky condition was intermediate with the global outdoor illuminance level estimated at 80,000 lx (Zain-Ahmed, et al., 2002). Nedhal et al. (2016) recommended the time for measurement was between 10.00 am to 4.00 pm, where minimum diffuse daylight was available and direct sunlight penetration can be avoided. Adhikari (2014) also mentioned that the human alertness was the highest at 10.00 am.

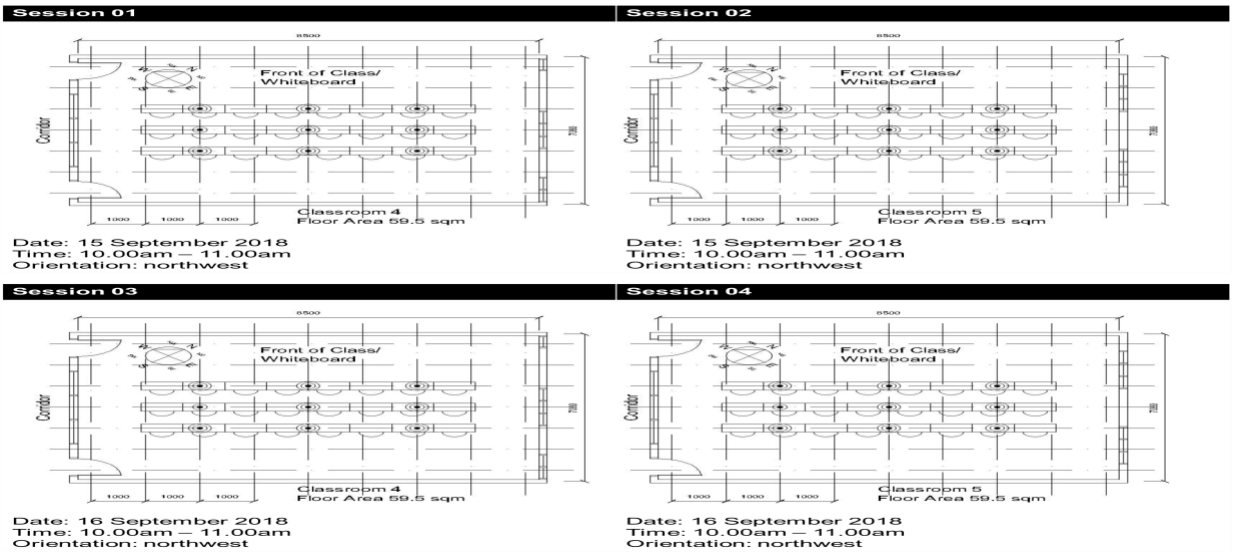

Fig. 4 Illuminance Level Lux Meter Position

4.2 Arabic Handwriting Performance

Methods in assessing students' performance varied depending on the selected tasks (Ferrier, et al., 2013). This study focused on the students' Arabic handwriting, where the time speed to finish rewriting the specific text was recorded to evaluate the students' Arabic handwriting performance. The performance

score was evaluated based on the word per minute (wpm) calculation, where the total of the letter written was divided with the time speed recorded (minute) with the average 5 letters for each word as shown in Eq. (1). The average words per minute (wpm) for students aged 13 to 14 years old was referred between 14.3 wpm to 15.6 wpm (Ziviani & Watson-Will, 2010).

(letter written/minute)/5 (1)

Students in both classrooms were required to rewrite the provided modified Balsam Alabdulkader-Leat (BAL) acuity eye chart (Syaheeza et al., 2019) using a *rehal* with 300mm working plane height to simulate the students' Arabic handwriting task performance. The Balsam Alabdulkader-Leat (BAL) eye chart was the result of a study on Arabic eye acuity test (Balsam, 2017), which was modified to follow Jaeger eye chart for the writing task performance score required in this study. The modified BAL eye chart was as shown in Fig. 5.

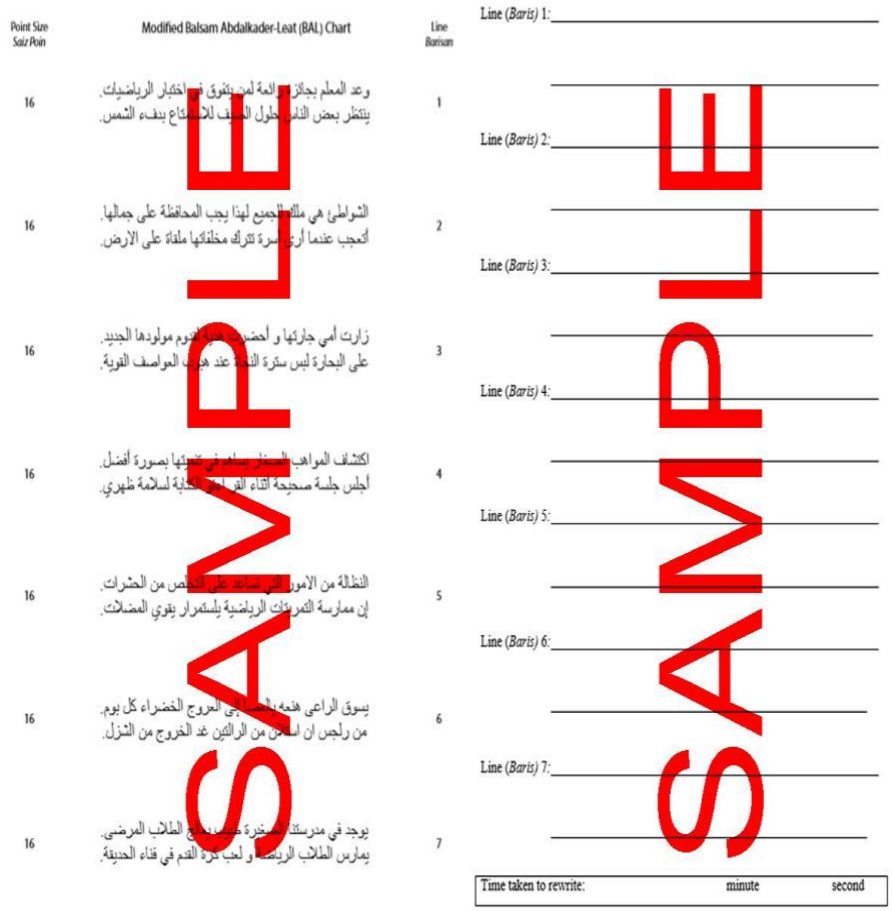

Fig. 5 Modified Balsam Alabdulkader-Leat (BAL) chart (Syaheeza et al., 2019)

5. Data Collection

The data collection for this study consisted of two parts, which were the average illuminance level and students' Arabic handwriting performance based on word per minute (wpm) score. The concern for the students' Arabic handwriting performance was the Hawthorne effect, where the students' behaviour changed during the performance assessment due to the students' awareness of being observed or assessed (McCarney et al., 2007; Fox et al., 2008). This undermined the findings of the data collected due to the

questionable integrity between the variables (Salkind, 2010). A Preventative approach to avoid the Hawthorne effect was to use hidden observation, even though knowing that they were participating in a study also potentially induced the Hawthorne effect (Persell, 2016). The observers for this study had clarified that the students should perform the Arabic handwriting tasks as per normal teaching and learning sessions instead of a competitive session.

5.1 Average Illuminance Level

The average illuminance level was measured at 300mm working plane height while the students were seated in position as a measure to consider the daylight fluctuation factor (Husini, 2016). The measured average illuminance level is as shown below in Fig. 6.

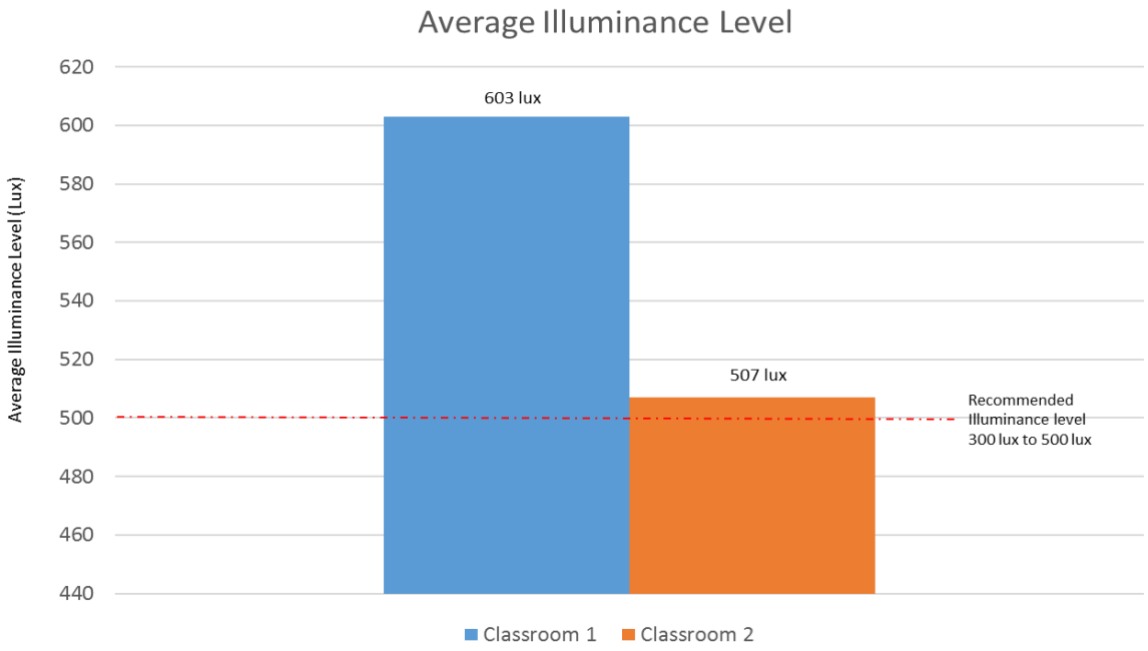

Fig. 6 Average Illuminance Level in Classroom 1 and Classroom 2

The average illuminance level measured at 300mm working plane height in each classroom exceeded the recommended illuminance level by standards and guidelines, where Classroom 1 was 603 lx and Classroom 2 was 507 lx. The difference of average illuminance level in Classroom 1 was 103 lx (20.6%) higher than maximum recommended illuminance level of 500 lx, while Classroom 2 was 7 lx (1.4%) higher. In theory, both classrooms were not suitable for learning task performance such as reading and writing due to high illuminance level. However, these results were compared with the students' Arabic handwriting performance score to identify the effect of the illuminance level on the students' performance.

5.2 Average Arabic Handwriting Performance

The students' Arabic handwriting time speed recorded was used to calculate the students' performance based on words per minute (wpm) score. The results of the students' writing performance based on wpm were as shown in Table 2. The data were analysed using Statistical Package for the Social Sciences (SPSS) descriptive functions. Students in Classroom 1 average writing performance (mean) was M=9.4 wpm and Classroom 2 was M=12.6 wpm.

Table 2. Students' Performance Descriptive Analysis Result

Students' Performance	Average Writing Performance (wpm)	
	Mean (M)	Median (MD)
Classroom 1	9.4	9.3
Classroom 2	12.6	12.2

Students in both classrooms had a very low average Arabic handwriting performance compared to students with the same age group, which was between 14.3 wpm to 15.6 wpm. The results also explained that students in Classroom 2 performed better compared with students in Classroom 1, which suggested that higher illuminance level negatively affected the students' Arabic handwriting performance. This can be assumed that higher illuminance level caused visual discomfort to the students such as glare. Fig. 7 shows the chart for the average Arabic handwriting performance score in both classrooms.

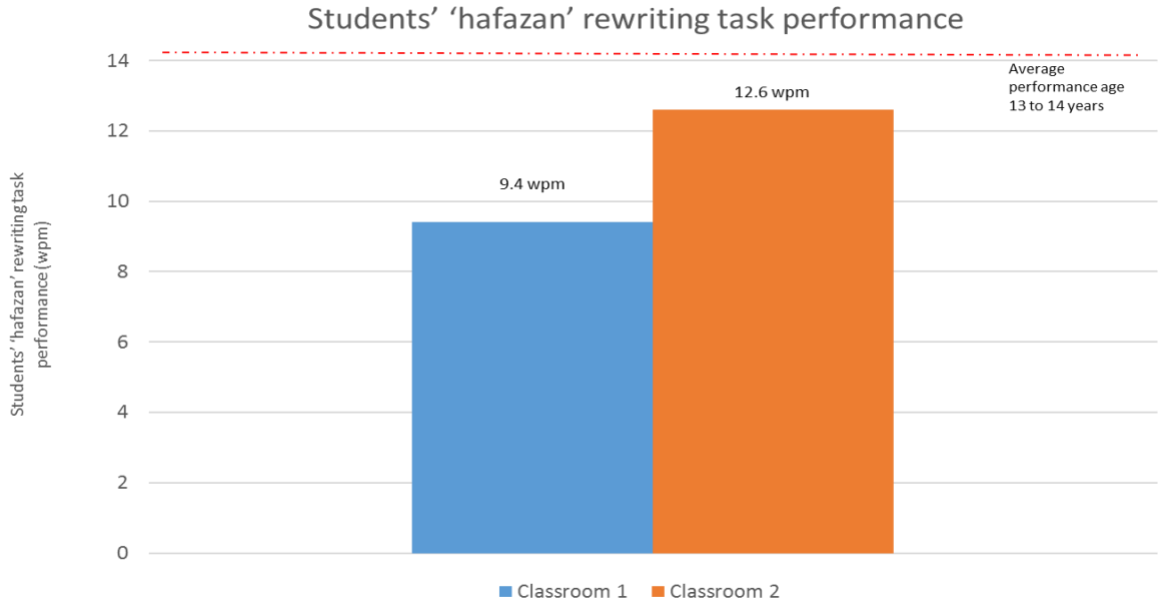

Fig. 7 Average Arabic Handwriting Performance in Classroom 1 and Classroom 2

6. Result and Discussion

Students in both classrooms scored a very low Arabic handwriting performance, albeit that Classroom 2 students performed better and higher compared to Classroom 1. Early conclusion was that both classrooms were not suitable for Arabic handwriting task performance for the hafazan learning process that required the students to read, write and recite the Quran verses. Table 3 shows the comparison between the students' Arabic handwriting performance and the average illuminance level measured in each classroom.

Table 3. Students' Arabic Handwriting Performance and Average Illuminance Level

Classroom 1				Classroom 2			
Illuminance Level (Lux)		Writing Performance (wpm)		Illuminance Level (Lux)		Writing Performance (wpm)	
603	high	9.4	very low	507	high	12.6	low

This shows that students' Arabic handwriting performance has improved when the illuminance level in a classroom was lower. This can be assumed that higher illuminance level in the classroom created

glare, thus causing visual discomfort for the students to perform learning tasks efficiently. Even though Classroom 2 average illuminance level was only slightly higher compared with the recommended range of 300 lx to 500 lx, the students' performance was still lower than the minimum average performance score of 14.3 wpm for the same age group. Average illuminance level that was approximately 100 lx (20%) higher than recommended range proved to significantly reduce the students' performance, as recorded in Classroom 1. Even though the method used in the study had a potential for Hawthorne effect to occur, the results showed otherwise. The students' average Arabic handwriting performance was still lower even though the students were aware about involvement in the assessment. Hence, the inefficient average illuminance level significantly influenced the students' performance negatively.

6.1 Implication on School Education

The study suggested that the classroom layout design for Islamic religious schools should be further studied based on the indoor daylight conditions suitable for *hafazan* education in Malaysia. Variables such as window-to-wall ratio (WWR) or window-to-floor ratio (WFR), window sill and head height, working plane height, materials and finishes have to be studied in order to improve the existing Islamic religious school design in Malaysia. The existing standards and guidelines also can be referred to in order to justify a new daylight rule of thumb for Islamic religious schools in Malaysia. Since the illuminance level measured at lower working plane height was different compared to a standard table height, students' specific tasks at different working plane heights also can be emphasized. This shows that the implication of this study is not only limited to students' performance and acceptable illuminance level at lower working height, but the classroom design, daylight rule of thumb, and teaching and learning method for Islamic religious schools in Malaysia as well. This study also hopefully will give awareness to architects, designers, authorities, government and Islamic religious schools and institution management on the importance of acceptable illuminance level for students' learning performance.

7. Conclusion

The findings showed that both Classroom 1 and 2 were not suitable for *hafazan* education using *rehal* with 300mm working plane height, where both average illuminance levels were higher than recommended. The high average illuminance level has caused the students' performance to decrease significantly due to the visual discomfort caused by glare. The relationship between the measured average illuminance level and the students' Arabic handwriting performance suggested that lower average illuminance level can improve the students' Arabic handwriting performance for *hafazan* learning process at a lower working plane height such as *rehal*. Thus, further study is required to identify the actual acceptable average illuminance level for *hafazan* learning tasks such as reading and writing at *rehal* working plane height of 300mm. Obviously, the study can be explored and extended to other variables such as reading tasks, classroom layout design for Islamic religious schools and many more. The findings of this study can be referred to by architects, designers and authorities to improve the classroom layout design in Islamic religious schools based on acceptable illuminance level for specific tasks at specific working plane height.

8. Acknowledgements

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