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ILLUMINANCE LEVEL AND ARABIC HANDWRITING PERFORMANCE AT LOWER WORKING PLANE HEIGHT

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Abstract

Renewable energy such as natural daylight is an important element that influences students' task performance such as reading and writing in schools. Research shows daylight can improve the students' performance in classroom. Acceptable illuminance level recommended by guidelines in the world for learning space is between 300 lux to 500 lux. The illuminance level is measured at the working plane 800mm to 900mm table height, where the window sill height is at the similar height. However, Ulul Albab education traditionally uses a book rest or 'rehal' for Quran 'hafazan' (Quran memorization) that requires Arabic handwriting tasks at working plane height between 250mm to 300mm. Focus of the paper is the students' Arabic handwriting performance at lower working plane height in classroom. The classroom selected in Kolej Permata Insan can seat 24 students based on the ratio of 2.5m2 floor area per student. The students using 'rehal' at working plane height of 300mm required to handwrite the modified Balsam Alabdulkader-Leat (BAL) eye chart to evaluate their performance based on word per minute (wpm). Results shows that students' Arabic handwriting performance in classrooms with average illuminance level of 603 lux and 494 lux measured at 300 mm working plane height were lower compared to the average of 13.7 wpm to 14.5 wpm. Thus, the average illuminance level measured at 'rehal' 300mm working plane height in existing classrooms were not suitable for Arabic handwriting task.

Keywords: Illuminance level, daylighting, working plane height, 'hafazan' education, students' performance.

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1. Introduction

Throughout the centuries learning spaces had changed for reasons regarding environment condition, construction technology, educational systems, government's policies and most importantly space requirement. A concept known as 'open-air design' was introduced in Europe circa 1904 that increases the design strategy towards improvement of natural daylighting and ventilation (Châtelet, Lerch, & Luc, 2003). Although the intention was improving the daylighting of learning space, 'open-air design' unexpectedly criticized for the amount of daylight received being too high and causes eyesore and glare to the students (Wu & Ng, 2003). Due to the importance of daylighting to students' learning performance development, various institutions including the government established standards and guidelines. Malaysian Standard 1525 (MS1525) (2014), Illuminating Engineering Society of North America (IESNA) and The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) are among the standards and guidelines that recommends illuminance level for learning spaces, where ASHRAE 10th edition includes a new illuminance determination procedure (DiLaura, Harrold, Houser, Mistrick, & Steffy, 2011). The illuminance level recommended is measured at 800mm to 900mm working plane height (GBI, 2009) in a typical classroom design. The recommended window sill height is not higher than three and a half feet or one meter (Baker, 2012). However, since Malaysia has various typology of educational institution such as Islamic religious school that requires different teaching and learning tools, the acceptable illuminance level varies between specific tasks required. Exemplified with the usage of a book rest or 'rehal' in traditional Ulul Albab education since Seljuq Dynasty in 10th century (Fuady, 2015). The 'rehal' working plane height is between 220mm to 300mm, which is suitable for squatting or crossed-leg position (Neufert, Neufert, & Kister, 2012; Adler, 2007). Since the measured illuminance level varies depending on the height of the working plane, the average illuminance level measured at lower height working plane and its effect towards the students' performance is the main focus of this study.

1.1. Literature Review

The literature review provided for this study is related with the daylighting standards and guidelines implemented, the students' performance affected by illuminance level, religious schools in Malaysia and students' Arabic handwriting performance.

1.1.1. Preferred illuminance level in standards and guidelines

The range of illuminance level recommended is based on the visual comfort during activities and tasks required such as reading and writing. Lighting quality (MS: 1525, 2014) is a lighting practice code that requires sufficient indoor lighting provided in any space. Table 1 below shows the average illuminance level required recommended regarding common reading tasks.

Table 01. Common reading task illuminance required.

Task	Illuminance (fc)	Illuminance (lux)
Printed material	30	323
Pencil writing	70	753
Good duplicated material	30	323
Poor duplicated materials	100	1076

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Elina (2016) mentioned that the indoor lighting condition in workspace influences the occupant's comfortability in performing the work accordance with required office task. Other than illuminance level, other architects and researchers referred the recommended daylight factor (DF) for various task at 1.5% (Lim, 2014), even though the intensity is too high for Malaysia tropical climate and condition (Arabi et al., 2018). Arabi added that daylighting intensity and brightness that is too high creates glare and visual discomfort to the occupants. Through the literature review for the study, the only standards and guidelines that differs from others is Educational Facilities Manual (EFM) Philippines that recommends illuminance level for classrooms as low as 215 lux to 430 lux.

Table 02. Standards and Guidelines in Malaysia and other country

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

Above shows Table 1 that exemplify the recommended illuminance level from various standards and guidelines in Malaysia and other guidelines. All of the standards in Malaysia stated similar illuminance level range between 300 lux up to 500 lux following the existing recommendation in IESNA. However, illuminance level measured at lower working plane height has different value. Thus, this research will also evaluate the average illuminance level at lower working plane in a typical classroom with 900mm window sill height.

1.1.2. Daylighting and students' performance

Efficient illuminance level provided by daylighting in classrooms effect the students' learning performance significantly (Vi Le, Gillott, & Rodrigues, 2016). Inappropriate visual comfort due to insufficient daylighting develops the students' performance poorly (Gilavand, Gilavand, & Gilavand, 2016). Through analysing the students' test score shows that it effects the students' behaviour and performance significantly (Heschong, Wright, & Okura, 2002). Various research on daylighting shows significant relation with energy efficiency, it increases the students' learning outcomes (Ibrahim & Ahmad, 2013) that can be seen in reading task performance (Arabi, Husini, Syaheeza, Dodo, & Kandar, 2018). Due to this factor, daylight should be considered in classroom for its positive impact towards students' psychology, health, learning performance such as cognitive skills, cognitive performance, subjective moods, physical activities, attention span, sleep quality, social skills and alertness (ZUMTOBEL, 2017; Shishegar & Boubekri, 2016; Yacan, 2014). Poor lighting in the classroom proven to influence the students to feel sleepy, thus reduces their focus during lessons period (Samani & Samani, 2012). Proven that students in a better daylight classroom can learn to perform reading task 26% faster than students in a classroom with low daylight performance (Erwine, & Heschong, 2002). The students' learning ability is related to physiology, which can be improved by increasing the light efficiency in the classroom (Edwards & Torcellini, 2002). Case studies on green schools proven the theory that better lighting in classrooms is highly associated with the improvement of the students' performance (Issa, Rankin, Attalla, & Christian, 2011; Demir & Konan, 2013; Erwine & Heschong, 2002). However, too

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high daylighting in the classroom can result in negative impact to the students' performance due to the glare that causes visual discomfort (Plympton, Conway, & Epstein, 2000).

1.1.3. Islamic religious school education in Malaysia

During the launching of the national mosque in 1966, the prime minister of that time Tunku Abdul Rahman Putra Al-Haj established a Tahfiz Institution, an idea coined by Sheikh al-Azhar Sheikh Mahmud Syaltut (Hassan, Fakhruddin, Ayub, Mutalib, & Jaafar, 2015). The demand for schools based on Islamic religious education known as Ulul Albab increases from 58 institutions in 1999 to 278 institutions in 2011 (Bani, Katan, Noor, & Fatah, 2014). Tahfiz school can be defined as any regular government schools with standardised curriculum that inserted Islamic religious subjects and moral pedagogy (Hassan et al., 2015). Ministry of Education Malaysia (MoEM) circulated a General Circular stating that public secondary schools will implement Ulul Albab pedagogy (MoEM, 2016). The deputy prime minister in 2016 second the motion, where his statement was that every public schools should implement Islamic religious education. Most of the religious school establishment in Malaysia referred to 'madrasah' pedagogy originated during the 10th century of Seljuq Dynasty. The term *'madrasah'* itself can be defined as secular and religious learning centres or institutions (Asimov, 1999). *'Madrasah'* was to be known when the political influence established a clear separation of institution between core religious institution such as mosque foe Islamic rituals and education institution such as a well-known *'madrasah'*, Madrasah Nizhamiyah during the Seljuq Dynasty. One significant historical factor to this research is that 'madrasah' during the Seljuq Dynasty uses a small table or *'rehal'* during the *'hafazan'* (Quran memorisation) at height between 2200m to 300mm, as stated by Michael Stanton (Fuady, 2015).

The Quran memorisation method that involves recitation of the Quran has been recognised by psychologists as a long term memory retention process (Fadhilah & Ashaari, 2015). Seljuq Dynasty uses *Sama'i* (listen) and *Jama'* (recite together) method during the Quran memorisation, which involves the teacher to recite the verses and students follow the recitation (Fuady, 2015). Other than Sama'i and Jama' other two methods are known as *Wahdah* (read one by one) and *Kitabah* (write) as generally identified by Ikhwanuddin and Hashim (2014). Methods identified by other researchers were writing *(Tahriri)*, reciting *(Syafawi)* and check the memorisation (*Tasmi'*) (Hashim, 2015). *Tasmi'* method is commonly used in 'madrasah', where the teacher is to listen to the students' recitation (reading), rewriting of the verses or both individually for each student (Abdullah, Safar, Mustari, Muhammad, & Ismail, 2003).

1.1.4. Arabic Handwriting Performance

Test of Legible Handwriting (TOLH) by Larsen and Hammil (1989) records the time speed taken for the students aged 7 to 18 to finish the writing task, where the word per minute (wpm) identifies the handwriting performance (Roger & Case-Smith, 2002). Common wpm calculation divides the written words by the minutes taken to finish, then divide by five average letter per word (Ziviani & Watson-Will, 2010). Incorrect written letters are not accounted or penalized for the evaluation (DeCoste & Scholkopf, 2005). Medwell, Strand, and Wray (2009) identified three measures in handwriting, which are:

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i. Handwriting (SAT) - handwriting style and neatness are assessed.
ii. Handwriting speed - copying test for students' handwriting speed in letters per minute (LPM)
iii. Alphabet task - measured by the alphabet form of the writing task, writing as many letters in lower-case in one minutes, alphabet letters per minute (ALPM).

The handwriting evaluations requires the respondents to handwrite sentences such as "the quick brown fox jumps over the lazy dog" theme to measure handwriting task performance (Prunty, Barnett, Wilmut, & Plumb, 2013). Other handwriting evaluation such as Handwriting Proficiency Screening Questionnaire (HSPQ) and Children's Questionnaire for Handwriting Proficiency (CHaP) indicates handwriting deficiencies with Likert scale type for three domains (Engel-Yeger, Nagauker-Yanuv, & Rosenblum, 2009; Rosenblum, Parush, & Weiss, 2015):

i. legibility
ii. performance time
iii. physical and emotional well-being.

Detailed Assessment Speed Handwriting (DASH) is the only standardized speed test that evaluates handwriting and speed performance of students based on various writing tasks in United Kingdom, where the evaluation includes (Prunty et al., 2013):

i. Copy Best – number of words written based on provided sentences, wpm scores
ii. Copy Fast – similarly with above, students required to write as fast as possible
iii. Free Writing – Students are required to write on a topic for 10 minute, wpm scores

Most of the handwriting performance evaluation records the speed of the handwriting task in order to identify the students' handwriting performance. Various handwriting performance evaluation for students introduced are based on English alphabets. Erez and Parush (1999) introduced Hebrew Handwriting Evaluation (HHE) to evaluate Hebrew handwriting performance instead of English alphabet (Rosenblum, Parush, & Weiss, 2003). The average wpm for secondary students ranged 13 to 14 years old is between 14.3 wpm to 15.6 wpm. However, wpm for Arabic and Hebrew performance (Ziviani & Watson-Will, 2010) due to the recursive style writing. The Arabic chart closely resembles English alphabet "the quick brown fox jumps over the lazy dog" theme for handwriting performance evaluation is Balsam Alabdulkader-Leat (BAL) eye chart. The BAL eye chart Arabic paragraphs and sentences validated were measured based on reading acuity (RA) and reading speed in standard-length words per minute (SLWPM). Results of normal visual acuity for the eye chart was calibrated with linear regression analysis (Balsam & Leat, 2017). The initial BAL eye chart adapted Colenbrander chart with similar grade level of difficulty (Balsam & Leat, 2016). The BAL eye chart has been modified similarly to Jaeger eye chart to evaluate the students' Arabic handwriting performance in this study.

2. Problem Statement

Through various references to standards and guidelines, the acceptable illuminance level required in learning spaces has been established between 300 lux to 500 lux. However, these illuminance level is

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measured according to various recommendation, such as Green Building Index (GBI) at 800mm to 900mm working plane height. This is due to the typical table height used in classrooms is also between 800mm to 900mm. This illuminance level measurement method and recommendations is not suitable to be referred in classrooms that uses lower table height such as 'rehal', which has lower working plane height between 220mm to 300mm. Since that Islamic religious schools in Malaysia uses 'rehal' to perform Arabic handwriting tasks for 'hafazan', the illuminance level measured at 300mm working plane height differs. These difference influences the students' Arabic handwriting performance, where students' handwriting performance assessment can evaluate the results. However, Arabic handwriting performance assessment has not yet been established.

3. Research Questions

This paper reviews research questions regarding the acceptable illuminance level measured at lower working plane height for Arabic handwriting task as follows:

3.1. What are the relationship between illuminance level, students' Arabic handwriting performance and different working plane height?

3.2. What is the average illuminance level measured at different working plane height?

3.3. How to measure the students' Arabic handwriting performance?

3.4. How is the students' Arabic handwriting performance at different working plane height**?**

4. Purpose of the Study

This research looks into the acceptable average illuminance level in classrooms measured at lower working plane height, which relates to lower table height such as kindergarten tables or more specifically 'rehal' used in Islamic religious schools. The study identifies whether the average illuminance level measured at normal working height of 900mm and 300mm is acceptable or not for Arabic handwriting tasks used for 'hafazan' education. However, the same method can be adapted to evaluate students' performance at lower working plane height for other types of education or curriculum.

5. Research Methods

The selected classrooms for the experiments were located in Kolej Permata Insan, USIM, Nilai. The school adapts the Ulul Albab pedagogy in the standardised government curriculum. The classrooms were built based on standardised design required in Guidelines and Regulations for Building Planning (GRBP), where classrooms should accommodate 2.5m2 area per student. The selected classrooms were approximately 60m2 in area, which can occupy 24 students per session. The first phase was to measure the average illuminance level of the classrooms. The illuminance level point measurement grid was approximately 1m x 1m, where the measuring tools were positioned 2m away from the windows (Sarith, 2013) to avoid high daylight intensity as shown in Figure 1 below.

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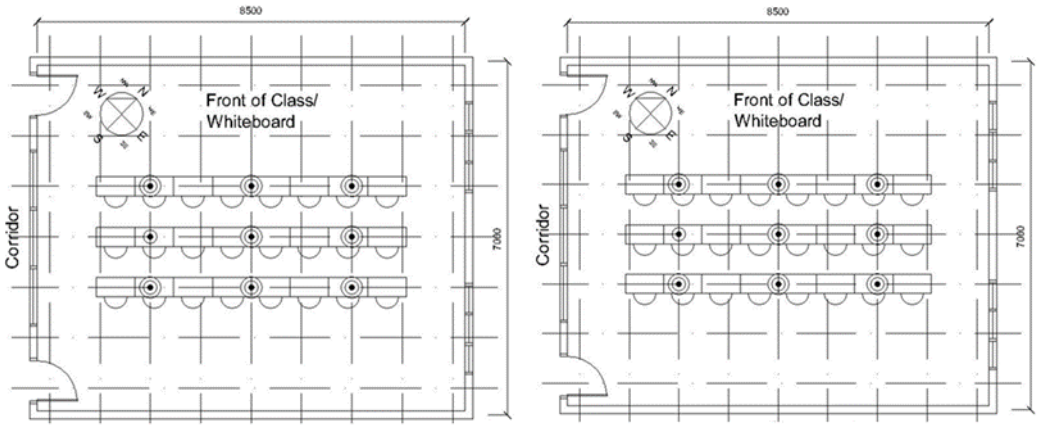

Figure 01. Classroom One (left) and Two (right) floor plan layout and illuminance spot measurement grid

The Window-to-Floor Ratio (WFR) of the classrooms selected were approximately 15%, thus lower than recommended in MS1525 as shown in Figure 2 below. However, the research examine the experiment based on the average illuminance level of the classroom and the students' Arabic handwriting task performance. Both classrooms were located on the second floor of the school to avoid immediate obstacle to the window. Students in both classrooms uses 'rehal' at 300mm working plane height to perform the Arabic handwriting performance in classrooms.

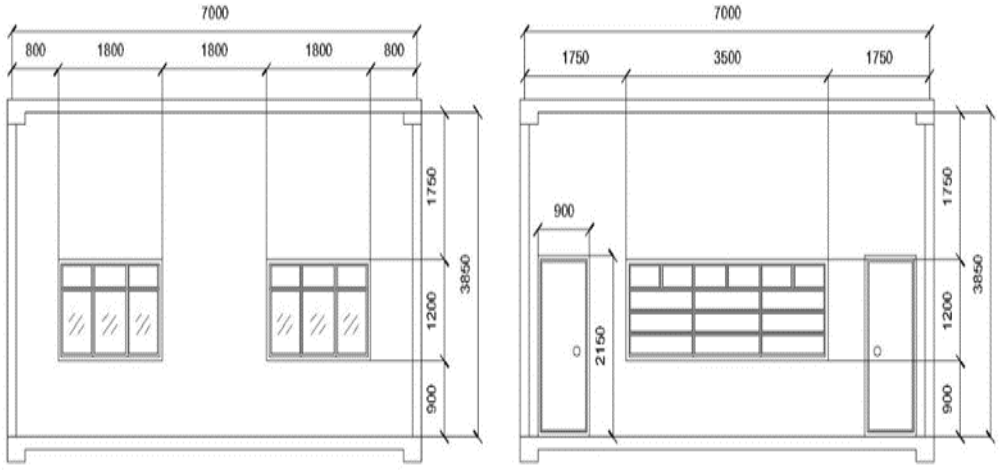

Figure 02. Side elevations of Classroom One and Two

The second phase of the research was that the students were required to rewrite the provided modified Balsam Abdulkader-Leat (BAL) Arabic chart in the provided space. The time speed taken for the students to finish the rewriting task was recorded to identify the students' average performance based on word per minute (wpm). The students' rewriting task were compared with the measured average illuminance level in each classroom.

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5.1. Illuminance level

The illuminance level measuring tools were placed on a 'rehal' 300mm working plane height in both classrooms to measure the average illuminance level. The average illuminance level is recorded with the students occupying the classroom. This is to record the actual illuminance level measured after the daylight fluctuation taken into consideration (Elina, 2016). The measured average illuminance level for Classroom One and Two are shown in Figure 3 below.

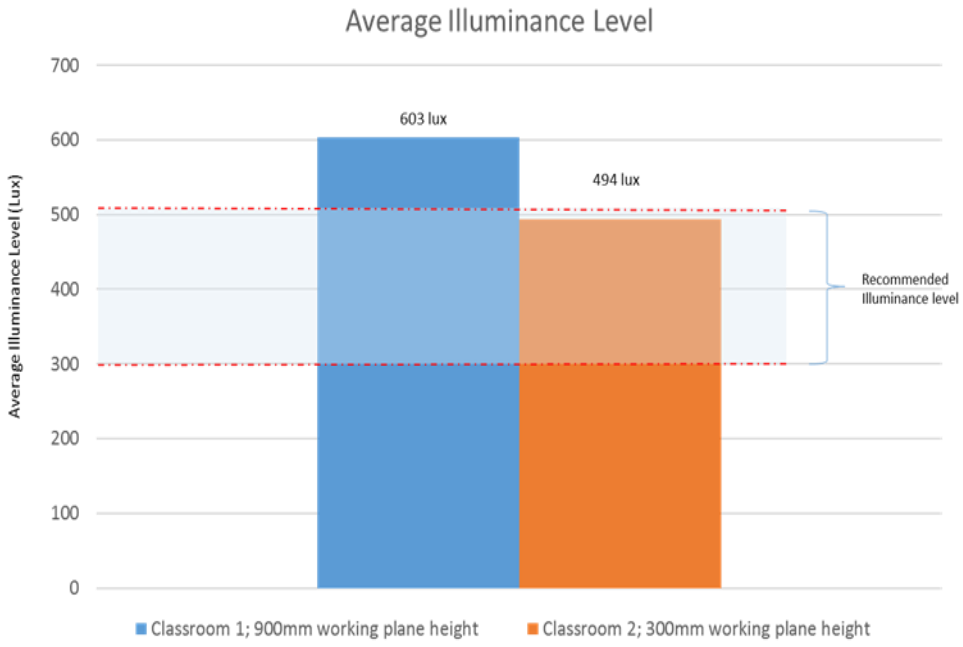

Figure 03. Selected classrooms average illuminance level graph

The average illuminance level measured in Classroom One is 603 lux, which is higher than the maximum recommended value of 500 lux based on standards and guidelines. Average illuminance level measured in Classroom Two at the same 300mm working plane height is 494 lux, within the recommended value between 300 lux to 500 lux. In theory, Classroom One is not suitable for students' optimum learning performance such as Arabic handwriting, where Classroom Two is suitable for optimum learning performance However, the recorded average illuminance level will be compared with the students' Arabic handwriting performance based on word per minute (wpm) to identify the suitability of classroom for Arabic handwriting in Quran memorisation.

5.2. Arabic handwriting task performance

The students are required to rewrite the provided modified Balsam Alabdulkader-Leat (BAL) eye chart and record the time speed to finish the rewriting task. The modified BAL eye chart is taken from a research on Arabic eye acuity test by Balsam and Leat (2017), where the application is to evaluate the respondents' eye acuity and reading performance. The modified BAL eye chart adapts Jaeger eye chart format with each lines are the same font sizes with different words as shown in Figure 4 below.

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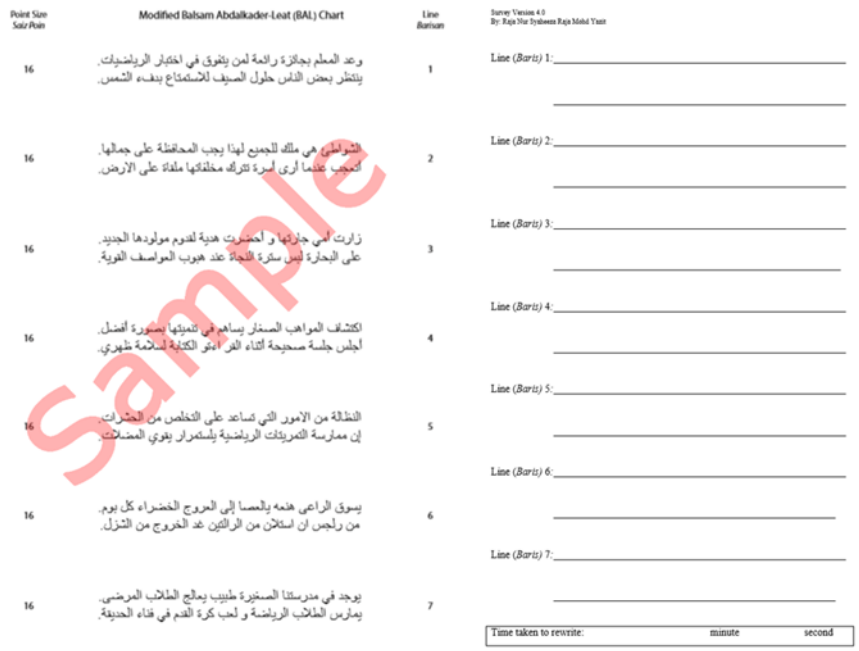

Figure 04. Modified BAL chart

Table 3 below shows the descriptive analysis of the students' writing task performance (wpm) using Statistical Package for the Social Sciences (SPSS) 25. The results of the students' average writing speed show that students in Classroom Two Arabic handwriting task is faster than Classroom One, with the average or mean of m=841 sec compared with m=920 sec respectively. The average writing speed recorded is to evaluate the students' Arabic handwriting performance based on wpm=word/minute/5.

Table 03. Students' writing task performance (wpm) results

Students' performance	Average writing speed (sec)		Average writing performance (wpm)	
	Mean	Median	Mean	Median
Classroom One	920	908	9.4	9.3
Classroom Two	841	796	10.5	10.5

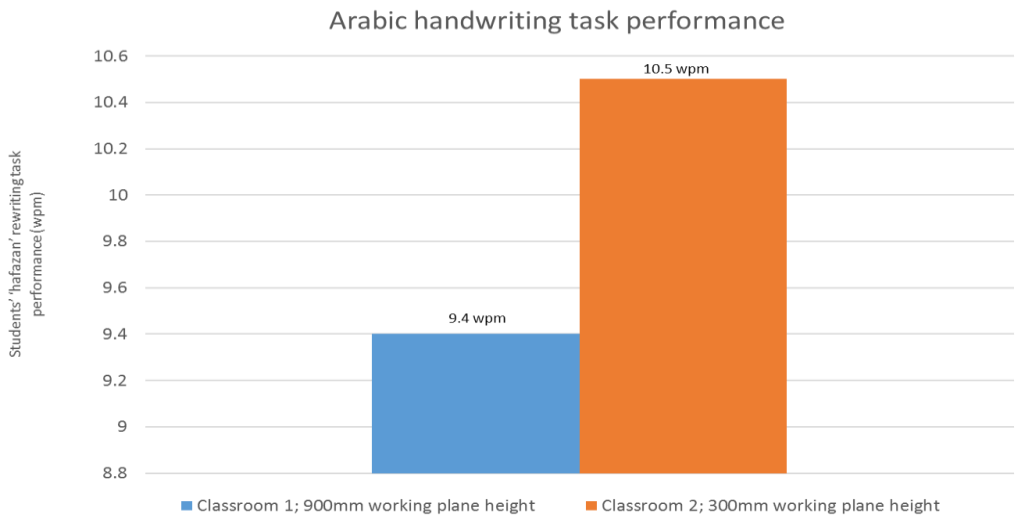

Figure 05. Students' questionnaire results on Daylight Condition Perception

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Figure 5 above shows the chart to represent the result discussed. Students aged 13 to 14 years old average writing performance is between 14.3 wpm to 15.6 wpm, with exception of Arabic alphabets should be lower (Ziviani & Watson-Will, 1998). The average of wpm for Classroom One is m=9.4 wpm, too low compared to the average mentioned previously. Students in Classroom Two in the other hand achieved higher average wpm of m=10.5 wpm. Although, both students achieved a very low average handwriting performance, even for Arabic alphabet handwriting.

6. Findings

The students' Arabic handwriting task performance identified by the word per minute (wpm) shows that both classroom have different average wpm, although both classrooms achieved very low average wpm for their age. Even though the average illuminance level of the Classroom Two at 300mm working plane height within the recommended 300 lux to 500 lux, the Arabic handwriting performance is still low. The small difference of average illuminance level in both classrooms shows correlation with the Arabic handwriting performance, where a lower illuminance level improves the wpm of the students. Table 4 below shows the discussed results.

Table 04. Average Illuminance Level and Students' 'Hafazan' Rewriting Task Performance

Classroom 1				**Classroom 2**			
Illuminance level (lux)		Writing performance (wpm)		Illuminance level (lux)		Writing performance (wpm)	
603	Very high	9.4	Very low	494	high	10.5	low

The students' Arabic handwriting performance in Classroom One shows that very high average illuminance level measured at typical table working plane height of 300mm in the classroom decreases the students' wpm. Average illuminance level for Classroom Two is still within the recommended range. However, the Arabic handwriting performance still low.

7. Conclusion

The result shows that at working plane height 300mm requires average illuminance level of lower than 500 lux to increase the students' Arabic handwriting task performance. Classroom One students' poor Arabic handwriting task performance is due to high intensity of daylight that causes glare and visual discomfort. This research also shows that average illuminance level measured at a lower working plane height in classrooms with 900mm window sill height is not suitable for Arabic handwriting task. This research requires further study to expand the understanding and knowledge of daylighting effect towards students' Arabic handwriting task performance at different working plane height.

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