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ARTICLE
THE OCCUPANTS' VISUAL ACUITY AND PERFORMANCE: METHODS FOR MEASURING OCCUPANTS' VISUAL AND WRITING PERFORMANCES IN DAYLIGHT SPACES

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ABSTRACT

Acceptable illuminance level in spaces is essential for optimum task performance that requires visual efficiency such as reading and writing. Passive design strategies are developed to meet the occupants' visual comfort such as optimizing the daylight source. Previous researcher highlighted the illuminance level in a space correlates with the occupants' performance, where the illuminance level which is higher and lower than the recommended by the guidelines decreases the overall performances of the respondents. The guidelines and standards highlighted the acceptable illuminance level in office and school are between 300 lux to 500 lux. Various methods have been developed to identify the reading and writing performances of occupants in relation to daylight and illuminance level. This paper aims to study suitable methods that can be developed in identifying the occupants' reading and writing performances in daylight spaces. The most common method to measure the respondents' writing performance is the speed (minute) and word per minute (wpm) of the respondents to complete the writing task such as Handwriting Speed Test (HST) and Detailed Assessment Speed Handwriting (DASH). Secondly is to explore the changes of illuminance level whether has relation to visual performance. Therefore, the visual test is conducted to identify the task performance within the range of acceptable illuminance level. The students achieved the high visual performance not at the recommended level of illuminance. The changes of illuminance level of 30 percent had influenced the student's visual performance. In order to control the lighting strategy, the lighting systems and sensors in learning spaces are suggested to stable the light intensity and contribute to energy consumption.

1.0 INTRODUCTION

Daylighting quantity and quality in buildings' assessments are significant in identifying the effects on visual comfort (Howlett et al., 2007). For an indoor space, daylight is measured using the illuminance level (lux) as the total luminous flux incident on a working surface (Husini et al., 2018). According to Green Building Index (GBI) in Malaysia, the illuminance level is recommended to be measured at 800 mm to 900 mm of the working plane height. This amount of the incident light will illuminate the working surface that correlates with the human perception of brightness level in a space (Ohno, 2005). Natural daylight in a space creates three effects on humans, which are known as 'Triple Effect' shown below (Zumtobel, 2018):

i. Visual functions
    a. Illumination of a task area in conformity with relevant standards
    b. Glare-free and convenient
ii. Creating biological effects
    a. Supporting the circadian rhythm
    b. Stimulating or relaxing
iii. Emotional perceptions
    a. Lighting-enhancing architectures
    b. Creating scenes and effects

Spaces that are designated for specific tasks or activities require appropriate environmental luminosity which has an optimum lighting quality (Veitch and Newsham, 1998). Lighting quality can influence:

i. visual performance,
ii. post-visual performance such as eating, reading, walking and all activities,
iii. communication and social interaction,
iv. mood state such as happiness, performance,

v. aesthetic judgment and
vi. safety and health.

Thus, the acceptable illuminance level in a space is required for the improvement of the occupants' visual performances in reading and writing.

2.0 LITERATURE REVIEW

This study explores the methods used to evaluate the respondents' reading and writing performances in daylight. The selected handwriting performance assessment has various ways to conduct for providing a study also looks at the Malaysian standards and guideline of the recommended illuminance level for reading and writing tasks, including the window-to-floor ratio (WFR) and window-to-wall ratio (WWR). The pilot study in this research is discussed based on visual and writing task performances. While the fluctuation light level that occurs in the room was significantly correspond to visual acuity.

2.1 Effects of Daylight on Occupants

The satisfaction of the performed tasks by occupants is highly influenced by the general indoor lighting conditions and environment (Husini, 2016). Various studies in schools show that the visual environment including the daylight intensity influences the occupants' visual stimuli, thus affecting their performance in class (Samani and Samani, 2012). Efficient light spectrum in a space with adequate daylight is a design strategy to reduce eye strain experienced by occupants (Heerwagen et al., 1998), and enhance health, productivity and performance of the occupants (Sojoudi, 2014; Rizal et al., 2016). Other health benefits from efficient daylight in a space are the improvement of eyesight, increased growth, improved immune system and less dental decay or cavities (Nicklas & Bailey, 1997).

It is undeniable that efficient daylight and illuminance levels in spaces such as classrooms have significant effects on the occupants' overall behavior, task performance and health (Heschong et al., 2002; Vi Le et al., 2016; Al-Ashwal & Hassan, 2018). In another view, a high light intensity or insufficient illuminance level in a space negatively affects the occupants' physiology, eye acuity, learning abilities and capabilities (Educational Facilities Manual, 2010; Gilavand et al., 2016; Arabi, et al., 2018). Other than improving the occupants' health and overall performance, efficient daylighting also improves their attention span, subjective moods, cognitive performance and alertness (Shishegar and Boubekri, 2016).

2.2 Handwriting Performance Assessment

The process of handwriting evaluation needs to be focused to identify the effect of the task performance. One of the common handwriting performance assessment methods is recording the time and speed of the rewritten text or alphabets by the respondents, sometimes with a limited time given (Ferrier et al., 2013). Another method is for the respondents to perform five tasks (Barnett et al., 2009):

i. copying with 'best' instructions,
ii. copying with 'fast' instructions,
iii. alphabet writing,
iv. 10-min free writing and
v. non-language-based task that involves drawing specific instruction.

Ferrier et al. (2013) used a different method with three principles, which are:

i. copying,
ii. writing to dictation and
iii. expository or narrative writing or 'free writing'.

Both Handwriting Speed Test (HST) and Handwriting Performance Test (HPT) require the respondents to rewrite provided sentences within 2 to 3 minutes (Ziviani and Watson-Will, 2010; Ferrier et al., 2013). The time speed recorded is used to obtain the respondents' word per minute (wpm) performance (Rogers and Case-Smith, 2002). Most of the research that uses handwriting assessment tools adopt the wpm calculation to evaluate task performance results.

However, Detailed Assessment Speed Handwriting (DASH) is one of the only standardized assessments that evaluate the handwriting products and speed performance. In addition, the Jaeger chart, a card that has texts with increasing font size (Khurana. 2008; Blesi et al., 2011) that evaluates the acuity result based on the smallest texts that can be read comfortably (Pal et al, 2006) has been modified and combined with Colenbrander chart to suit the handwriting assessment based on DASH (Syaheeza et al., 2018).

2.3 Word per Minute (wpm)

The word per minute (wpm) calculation is commonly used to evaluate handwriting performance, where the basis of wpm is that the speed per letter is divided with a varied average letter per word, based on demography and background. The varied average letter per word can be 1.5, 3 and 5 letters per word (Connelly et al., 2005). The most common average letter per word used is 5 letters per word (Ziviani and Watson-Will, 2010). There is no penalty or deduction in the performance evaluation for incorrect letters or words done by respondents (Keerthi and DeCoste, 2005).

2.4 Review on the Eye Acuity Chart

The eye acuity test has been developed extensively throughout history. A more reliable eye chart was the Bailey-Lovie eye chart or the Logarithm of the Minimum Angle of Resolution (LogMAR) eye chart (Hussain et al., 2006). The LogMAR eye charts consist of visually similar letters arranged randomly in ten lines with the same

number of letters, where the only difference between these lines is the font size, ranging from 4 to 36 points. The font used is bold Calibri with double spacing between the lines as shown in Figure 1 (Anter, 2013; Husini et al., 2017).

Figure 1. LogMAR eye chart

As mentioned by Mansfield et.al, (1994), the continuous text reading acuity chart can be evaluated based on the following's activities: -

i. Reading acuity – smallest print that can be read without any significant errors.
ii. Critical print size – smallest print that can be read with maximum speed.
iii. Maximum reading speed – reading speed when a reading task is not limited by the print size.

The most newly developed eye chart is the Balsam Alabdulkader-Leat (BAL) eye chart, which is specifically developed for the Arabic language (Alabdulkader and Leat, 2017) and used in visual performance evaluation. In this research, the BAL eye chart was used to provide a visual test for students with the Arabic language and suitable for these pilot studies.

2.5 Fluctuation of Illuminance Level

Light fluctuation is detected when the light level cannot be maintained as desired. The belief of light and performance has been identified by Hughes and Mc Nelis (1978). The performance of visual test through reading or writing task is associated with ranges of light level. Even though there is not significantly related to illuminance variation, but the task illuminance differed according task. (SY Kim,et.al., (2007). Meanwhile according to Husini et.al, (2018) the changes of illuminances resulted different perception and mood. The light fluctuation in incident light occurs when the prediction of perceptibility of the transient changes of light measured based on human eye brain system. (Afshar, 2006).

2.6 Standards and Guidelines

The influence of window-to-wall ratio (WWR), window-to-floor ratio (WFR), and illumination standards towards the daylight quality and visual performance are explained based on The Uniform Building by Law (UBBL) and Malaysian Standard 1525. Generally, the need to highlight WWR, WFR and illumination in this study is to enhance the sufficient room area or size and identify the direction of the light source. WFR is related to windows' configurations of any space which affects the daylight performance and environment of the space (Zomorodian et al., 2016).

UBBL Malaysia states that spaces for education should have 20 percent of WFR. On the other hand, Malaysian Standard 1525 (MS1525) highlights the recommended acceptable illuminance based on the visual comfortability of occupants. This is during any specific tasks which require a specific amount of illuminance level. Illuminating Engineering Society of North America (IESNA) recommends the average general background illuminance level should be between 300 lux to 500 lux for learning spaces (DiLaura, 2011), which also recommended by MS1525 and the Public Works Department (JKR) Technical Guide. Table 1 shows the recommended illuminance level for learning spaces. Across the standards and guidelines since 1925, the suitable WFR for learning spaces are 1/5 or 20%, where the inadequate design of windows causes a very high daylight intensity, which resulted in glare and discomfort to the students that can lead to poor learning performance.

Table 1. Recommended illuminance level in learning spaces

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

3.0 RESEARCH LIMITATIONS

The limitations of this research are described as follows:

i. The students were randomly selected by the administration of Kolej Genius Insan due to the students' class schedule.
ii. The age of the students selected is between 13 to 17 years old, where the students have the intellect to provide feedback based on their perceptions and experience.
iii. The only suitable month for the experiment was between February to March and August to October, based on the sun path diagram for efficient daylighting.

iv. The windows and openings are only on both side of the classroom with 20% WFR that follows the recommendation.

v. The illuminance level is measured in each classroom at 900 mm working plane height.

4.0 METHODOLOGY OF THE PILOT STUDY ON THE HANDWRITING PERFORMANCE

The selected method for investigating the students' handwriting performance is the Detailed Assessment Speed Handwriting (DASH) which focuses on the English alphabetical system. Other types of education systems around the world use different languages and alphabetical systems such as Arabic and Hebrew. Hebrew Handwriting Evaluation (HHE), is still lacking a reliable evaluation method for Arabic handwriting (Syaheeza, 2020). Since the pilot study in this research was looking into the Arabic Handwriting Performance Assessment prototype, the BAL eye acuity test based on the Arabic alphabet was preferred and relevant to test the students' Arabic handwriting performance in their current classrooms. The students who were randomly selected aged between 13 to 17 years old and have the background of Arabic language education system in Malaysia.

The students' performance was measured based on their Arabic handwriting word per minute (wpm), where the respondents were required to read, rewrite and record the time to finish rewriting the provided BAL chart. The students were not given any time limitation to rewrite the BAL chart. The modified BAL chart consists of seven same lengths but different sentences. The space between the sentences is eight-point size, where the gap between each sentence is 35 mm. The Arabic font used was 16-point size, where it is equivalent to the Times New Roman font point of 12. The Arabic eye chart was similarly constructed as "the fox jumps over the lazy dog". The total Arabic letters in the eye chart are 700 with an average of 100 Arabic letters per paragraph, where the average is 20 Arabic words per paragraph with a total of 140 Arabic words as shown in Figure 3. The numbers of the students for each classroom were determined based on the Guidelines and Regulations for Building Planning (GBRP), which allocates 2.5m2 per student. Each classroom with average floor area of 58m2 can fit 24 students for each session. Three sessions consisted of 24 respondents aged 13 and 14 years old seated in three rows where each session was allocated with eight students per row. Students used the typical school tables with the working plane height of 900 mm from floor level. The experiments were conducted between 10.00 am to 11.00 am due to the high alertness of the respondents (Adhikari, 2014) and minimum diffused daylight (Nedhal et al., 2016). Luminance spot measurement method was adapted to measure the illuminance level at working plane height, where the lux meters were placed on a 1m x 1m grid on the classroom floor layout (Zomorodian, 2016).

Figure 2. Modified BAL eye chart

4.1 Background of the Pilot Study

The first pilot study (Pilot Study 1) was conducted in Kolej Genius Insan, Universiti Sains Islam Malaysia (USIM), Nilai. This is to evaluate the students' Arabic handwriting performance by using the modified BAL eye chart. The students' performance evaluation was based on word per minute (wpm) and the illuminance level was measured in each classroom at the 900-mm working plane height. The second pilot study (Pilot Study 2) was conducted in a classroom at Malaysian Japan Institute Technology (MJIIT), Kuala Lumpur. This setting had 70% WWR of the opening, facing the east orientation. The illuminance level in the room is measured based on the current lux level. The lux level is monitored when the occupants are occupying the room to do handwriting assessment.

4.2 Pilot Study 1: Results and Discussion

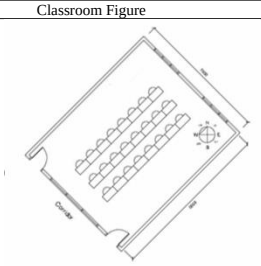
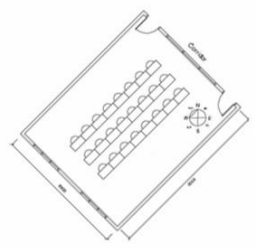
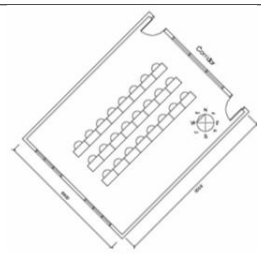
Classroom Figure			
Experiment 1	Classroom 1		Area: 59.5m² Orientation: southeast Glazing: northeast/ southwest Student pax: 24 student Window Sill: 900mm Working Plane: 900mm Window Head: 2.1m WFR: 20% Reflectance Floor: 0.3 (30%) Walls: 0.5 (50%) Ceiling: 0.7 (70%) Transmittance: 0.81(81%)
	Classroom 2		Area: 57.8m² Orientation: southeast Glazing: northeast/ southwest Student pax: 24 student Window Sill: 900mm Working Plane: 900mm Window Head: 2.1m WFR: 20% Reflectance Floor: 0.3 (30%) Walls: 0.5 (50%) Ceiling: 0.7 (70%) Transmittance: 0.81(81%)
	Classroom 3		Area: 57.8m² Orientation: southeast Glazing: northeast/ southwest Student pax: 24 student Window Sill: 900mm Working Plane: 900mm Window Head: 2.1m WFR: 20% Reflectance Floor: 0.3 (30%) Walls: 0.5 (50%) Ceiling: 0.7 (70%) Transmittance: 0.81(81%)

Figure 3. Classroom setup and information

The results of the three sessions in Pilot Study 1 show that the illuminance level and the students' performance are correlated, where a higher illuminance level in the classroom resulted in a lower students' performance (Figure 4). It shows that the method used to evaluate the students' handwriting was reliable due to the correlation between the students' wpm and the illuminance level in the classroom.

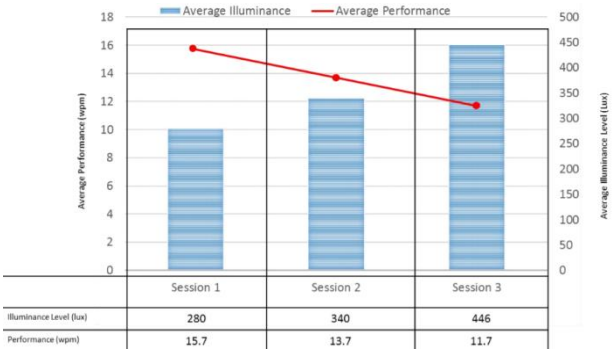


Figure 4. Illuminance level and students' performance

Session three shows that the performance of the students were lower compared to the other sessions, which can be related with the higher illuminance level that causes higher glare and visual discomfort during the students' handwriting performance. The illuminance level in Session 2 was lower, which resulted in better performance of the students. Similarly, this shows that illuminance level influenced the students' performance, where lower daylight intensity increases the students' visual comfort during their tasks, even though illuminance level that was too low caused the visual discomfort of the students. However, referring to Session 1, the illuminance level is lower than the recommended level of 300 lux, but the students have achieved wpm higher than the average performance of students in their age group. There was glare occuring in the room and this is why the students were confused to identify either insufficient daylight distribution or the effect of glare. Only 35% of the students were within acceptable writing performance, with speed between 10 min 58 sec to 12 min 54 sec. The fastest speed recorded was between 7 min 45 sec to 9 min 50 sec.

4.3 Pilot Study 2: Method for Visual Performance

Pilot Study 2 was focused on students in the MJIIT learning space. A series of visual tests were conducted to evaluate the lighting environment and visual performance based on the letter identification method by Roufs and Boschman (1997). The students' performance was measured based on their speed (minute) to read and identify the provided LogMAR eye chart. Similarly, the MNREAD eye chart can also be used.

4.4 Pilot Study 2: Results and Discussion

The results of the visual tests by students in the MJIIT classroom were recorded based on the time speed taken to complete the reading task. The students' performance was measured based on their Arabic handwriting word per minute (wpm), where the respondents were required to read and rewrite. Figure 5 shows the experimental set-up on the writing performance.

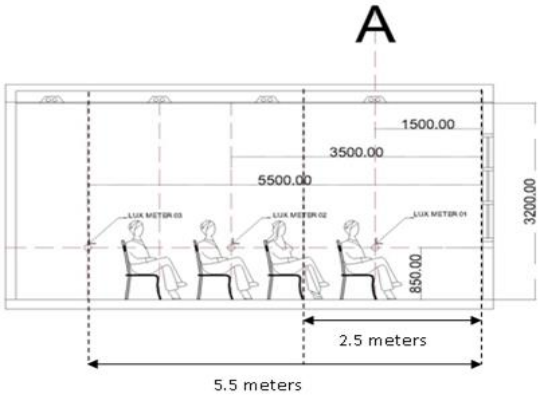


Figure 5. Experimental set-up on the writing performance

Table 2 shows the method used to identify the students' performance; the table records the time speed taken for them to finish reading the provided eye chart. The table shows that only 50 per cent of the students' performance scores at MJIIT were acceptable, where the time range was between 2 min 1 sec and 2 min 15 sec, with the fastest

speed recorded was between 1 min 16 sec and 1 min 30 sec. This score percentage was likely due to the illuminance level ranged between 401 lux and 599 lux, which was slightly higher than the recommended value in standards and guidelines. Meanwhile the percentage score at Kolej Genius Insan only 35 per cent of the students were performed. Based on table 2, it shows that the visual performance by students at MJJIT is better than the achievement of students at Kolej Genius Insan. The ranges of 400 lux to 599 lux seemed to be more accepted by students in their visual test compared to guideline.

Table 2. Result on scoring based on speed

	Range of Acceptable illuminance level (in daylighting)	Percentage Score (%)	The Fastest Speed (Time)	Words per minute (wpm)
MJIIT	401-599 Lux	50% (2 min 01 sec – 2 min 15 sec)	1 min 16 sec - 1 min 30 sec	17.7 – 14.8
College Genius Insan	280-446 lux	35% (10 min 58 sec - 12 min 54 sec)	7 min 45 sec - 9 min 50 sec	18.6 – 15.7

4.5 The Change of Illuminance (Fluctuation): Results and Discussion

The average lux level of 617 lux was measured of the empty classroom. The lux level was decreasing when the classsroom is occupied by 25 students. (Figure 6). The average lux level at seating area showed 430 lux. The change of illuminance level was detected. There was 30% reduction of lux level when the maximum of students were in the classroom. The daylight zone at seating area presented the lux level was higher than 300 lux which was stated in the recommended guidelines MS1525.

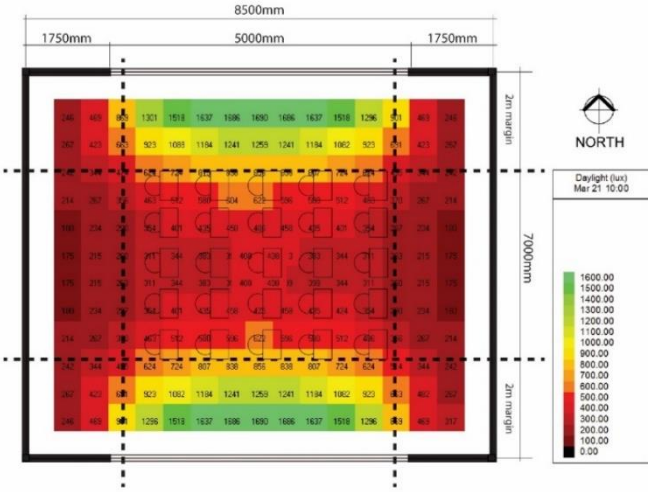


Figure 6. The Average Lux Level at Seating Area

5.0 CONCLUSION

Based on Pilot Study 1, using eye charts similar to the modified BAL eye chart such as the MNREAD, Jaeger and Colenbrander charts is suitable to evaluate the correlation between the students' performance based on handwriting performance (wpm) and the classroom illuminance level (lux). The second pilot study shows that 50% of the students were managed to score the task of lettering identification within the fastest speed. The parameters affected the optimal performance zone with an average quantity of illuminance. This visual test affected visual performance in a room with optimum 70% WWR and within the performance zone at the distance from the window of 2.5 m to 4.5 m. It is suggested that light controller detection for indoor spaces needs to be developed to reach the occupant's desire towards daylighting and visual performance. The acceptable illuminance level for students shows the different result of visual performance. The higher performance was achieved even the change of illuminance level was reduced at 30% and the ranges of illuminance level still at their tolerance. The change of illuminance level has significant with the visual performance. The indoor light controller can optimize the usage of electricity in a room and reduce energy consumption.

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7.0 REFERENCES

Adhikari, S. P. (2014). Chronobiology Overview and its Relevance in Psychiatry [PowerPoint slides]. Retrieved from https://www.slideshare.net/better2heart/chronobiolgoy-6378510.

Al-Ashwal. N. T. & Hassan, A. S. (2018). The Impact of Daylighting-Artificial Lighting Integration On Building Occupants' Health and Performance. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 9(2), 97- 105.

Alabdulkader, B. & Leat, S. J. (2017). A Standardized Arabic Reading Acuity Chart: The Balsam Alabdulkader-Leat Chart. Optometry and Vision Science, 94(8), 807-816.

Anter, K. F. (2013). Daylight Visual Comfort and Quality of Light, University College of Arts, Crafts and Design, Swedish Energy Agency: Sweden, 1-58

Arabi, F., Husini, E. M., Syaheeza, R. N., Dodo, Y. A. & Kandar, M. Z. (2018). Acceptable Illuminance Level Attributes to Learning Satisfaction in Classroom, International Journal of management and Applied Science, 4(3), 61-66.

Afshar, F. G. (2006). Light Flicker-Factor as a Diagnostic Quantity for the Evaluation of Discharge Instabilities in HID Lamps. LEUKOS, 3(1), 33-50.

Barnett, A. L., Henderson, S. E., Scheib, B. & Schulz, J. (2009). Development and Standardization of a New Handwriting Speed Test: The Detailed Assessment of Speed of Handwriting. British Journal of Educational Psychology Monograph Series II, Number 6, 137-157(21).

Blesi, M., Wise, B. & Kelley-Arney, C. (2011). Medical Assisting Administrative and Clinical Competencies. Cengage Learning. pp. 888–890.

Colenbrander, A. (2009). The Functional Classification of Brain Damage–Related Vision Loss. Journal of Visual Impairment & Blindness, 103(2), 118-123.

Connelly, V., Dockrell, J. E. & Barnett, J. (2005). The Slow Handwriting of Undergraduate Students Constrains Overall Performance in Exam Essays. Educational Psychology, 25(1), 99-107.

DiLaura, D. L., (2011). The Lighting Handbook: Reference and Application, Illuminating Engineering Society of North America (IESNA).

Educational Facilities Manual. (2010). Handbook on Educational Facilities, Department of Education.

Ferrier, J., Horne, J. & Singleton, C. (2013). Factors Affecting the Speed of Free Writing. Journal of Research in Special Educational Needs, 13(1), 66– 78.

Gilavand, A., Gilavand, M., & Gilavand, S. (2016). Investigating the Impact of Lighting Educational Spaces on Learning and Academic Achievement of Elementary Students, International Journal of Pediatrics, 4, 360–369.

Heerwagen, J., Johnson, J. A., Brothers, P., Little, R., & Rosenfeld, A. (1998). Energy Effectiveness and the Ecology of Work: Links to Productivity and Well-Being. In Proceedings of the1998 ACEEE Summer Study on Energy Efficiency in Buildings. Richland, WA (US): American Council for an Energy-Efficient Economy

Heschong, L., Wright, R. L., & Okura, S. (2002). Daylighting Impacts on Human Performance in School, Journal of the Illuminating Engineering Society, 31, 101-114.

Howlett, O., Heschong, L. & McHugh, J. (2007). Scoping Study for Daylight Metrics from Luminance Maps. The Journal of the Illuminating Engineering Society, 3(3), 201- 215.

Hughes, P. C., PC, H., & JF, M. (1978). Lighting, productivity, and the work environment.

Husini, E. M., Yazit, R. N. S. R. M., Arabi, F., Ismail, W. N. W., & Jaafar, N. H. (2018, September). Light, daylighting and fluctuation of illuminance level in office buildings. In IOP Conference Series: Materials Science and Engineering (Vol. 401, No. 1, p. 012021). IOP Publishing.

Husini, E. M. (2016). Occupant Density and Daylight Illuminance Level Fluctuation for Office Building in Malaysia. PhD thesis, Universiti Teknologi Malaysia, Faculty of Built Environment.

Husini, E. M., Arabi, F., Ismail, W. N. W., Kandar, M. Z., Jaafar, N. H. & Syaheeza, R. N. (2017). Daylight Factor Indicator for Discomfort Metrics in Learning Space Based on Acceptable Daylight Illuminance, Fundamental Research Grant Scheme (FRGS) USIM.

Husini, E. M., Syaheeza, R. N., Arabi, F., Ismail, W. N. W. & Jaafar, N. H. (2018). Light, Daylighting and Fluctuation of Illuminance Level in Office Buildings. IOP Conf. Series: Materials Science and Engineering, 401, 12-21.

Hussain, B., Saleh, G. M., Sivaprasad, S. & Hammond, C. J. (2006). Changing from Snellen to LogMAR: Debate or Delay? Clinical & Experimental Ophthalmology, 34(1), 6-8. doi.org/10.1111/j.1442-9071.2006.01135. x.

Kim, S. Y., & Kim, J. J. (2007). Influence of light fluctuation on occupant visual perception. Building and environment, 42(8), 2888-2899.

Keerthi, S. S. & DeCoste, D. (2005). A Modified Finite Newton Method for Fast Solution of Large Scale Linear SVMs. Journal of Machine Learning Research, 6, 341- 36

Khurana. (2008). Theory and Practice of Optics and Refraction. Elsevier India, India.

Mansfield, J. S., Legge, G. E., Luebker, A., & Cunningham, K. (1994). MNREAD Acuity Charts. Minnesota Laboratory for Low-Vision Research. Lighthouse Low Vision Products: Minneapolis.

Nedhal, A., Fadzil, S. F. S. & Adel, A. (2016). Relationship between Window-to-Floor Area Ratio and Single-Point Daylight Factor in Varied Residential Rooms in Malaysia, Indian Journal of Science and Technology, 9(33), 1-8.

Nicklas, M.G. & Bailey, G.B. (1997). Daylighting in Schools. Strategic Planning for Energy and the Environment, 17(2) 41–61.

Ohno, Y. (2005) Photometry*. In A. C. Parr, R. Datla & J. Gardner, [Ed] Optical Radiometry, Elsevier.

Pal, N, Titiyal, J. S., Tandon, R, Vajpayee, R. B., Gupta, S. & Murthy, G. V. (2006). Need for Optical and Low Vision Services for Children in Schools for The Blind in North India. Indian Journal of Ophthalmology, 54(3), 189-93. ISSN 0301-4738.

Rizal, Y., Robandi, I. & Yuniarno, E. M. (2016). Daylight Factor Estimation Based on Data Sampling Using Distance Weighting, Energy Procedia, 100, 54 – 64.

Rogers, J., & Case-Smith, J. (2002). Relationships Between Handwriting and Keyboarding Performance of Sixth-Grade Students. American Journal of Occupational Therapy, 56, 34–39.

Roufs, J. A. J. & Boschman, M. C. (1997). Text quality metrics for visual display units: I. Methodological aspects, Displays, 18(1), 37-43.

Samani, S. A., & Samani, S. A. (2012). The Impact of Indoor Lighting on Students' Learning Performance in Learning Environments: A knowledge internalization perspective, International Journal of Business and Social Science, 3, 127-136.

Shishegar, N., & Boubekri, M. (2016). Natural Light and Productivity: Analyzing the Impacts of Daylighting on Students' and Workers' Health and Alertness. International Journal of Advances in Chemical Engineering & Biological Sciences (IJACEBS), 3, 72- 77.

Sojoudi, S. (2014). Visual Comfort under Daylighting Conditions in Two School Classrooms in Malaysia. Master thesis, Universiti Putra Malaysia, Faculty of Design and Architecture.

Sue, S. (2007). Test distance vision using a Snellen chart. Community Eye Health, 20(63), 52. ISSN 0953-6833 https://researchonlinehegae.lshtm.ac.uk/id/eprint/20109

Syaheeza, R. N. (2020). Window Design for Optimum Classroom Daylight in Islamic School. PhD thesis, Universiti Sains Islam Malaysia, Faculty of Engineering and Built Environment

Syaheeza, R. N., Husini, E M., Arabi, F., Ismail, W. N. W. & Kandar, M. Z. (2018). Secondary School Classrooms Daylighting Evaluation in Negeri Sembilan, Malaysia, IOP Conf. Series: Materials Science and Engineering, 401, 12-24.

Veitch, J. A. & Newsham, G. R. (1998). Lighting Quality and Energy-Efficiency Effects on Task Performance, Mood, Health, Satisfaction, and Comfort, Journal of the Illuminating Engineering Society, 27(1), 107-129.

Vi Le, T. H., Gillott, M. C., & Rodrigues, L. T. (2016). The case for Hybrid Ventilated Primary Schools. In 36th International Conference on Passive and Low Energy Architecture, Ho Chi Minh City Vietnam

Ziviani, J. & Watson-Will, A. (2010). Writing Speed and Legibility of 7–14-Year-Old School Students Using Modern Cursive Script. Australian Occupational Therapy Journal, 45(2)

Zomorodian, Z. S., Korsavi, S. S. & Tahsildoost, M. (2016). The Effect of Window Configuration On Daylight Performance in Classrooms: A Field and Simulation Study, Int. Journal Architecture, Engineering and Urban Planning, 26(1) 15-24.

Zumtobel. (2018). The Lighting Handbook, Zumtobel Lighting GmbH.