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THE EFFECTS OF INTERNAL PARTITION ON INDOOR DAYLIGHTING PERFORMANCE OF STUDENT RESIDENTIAL BUILDING IN IPOH, PERAK

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ABSTRACT

The installation of an internal partition has resulted in lowering the illumination level inside a building. Therefore, this study is intended to evaluate the effects of several internal partition layout on indoor daylighting performance in student residential rooms. Several options of internal partition were simulated using Climate Based Daylight Modelling (CBDM) to suggest the effective partition layout to overcome low daylighting level inside the room at annual level. The findings indicate that the internal partition perpendicular to the window layout has been proven to haveo the highest annual daylight sufficiency in a student residential room in the tropics.

Keywords: *Internal Partition, Daylight, Simulation, Climate Based Daylight Modelling (CBDM)*

INTRODUCTION

Polytechnic education was introduced in Malaysia with the funding from the World Bank and a collaboration with the Colombo Plan in 1969. Currently, there are 33 polytechnics in the country which can be divided into three categories - premier, conventional, and metro. These polytechnics provide skilled semi-professionals in the fields of engineering, commerce, and hospitality at diploma and advanced diploma levels to meet the demand of the public and private sectors. The increasing number of students leads to the booming of multi-storey student residential buildings on the campuses. However, there is a lack of studies performed at the student residential building, especially in the tropical climate region, as compared to the office or commercial buildings in the temperate climate region (Jamaludin, Hussein, Keumala, Rosemary, & Ariffin, 2015). Usually, typical multi-storey hostel room layout has an open plan layout, and students stay in a shared accommodation with at most four students at one time. However, in this new hostel building, the rooms are designed with an internal partition and can accommodate six students at one time which has resulted in lowering the illumination level inside the room. This scenario has increased the dependence on artificial lighting, especially during daytime and consequently will increase energy consumption. This is converse to the previous study that merely focuses on student residential room with an open plan (Kumar, 2014; Pejic´, Petkovic´, & Krasic´, 2014; M. Al-Tamimi, Syed Fadzil, & Wan Harun, 2011).

LITERATURE REVIEW

Lower energy consumption can be achieved if passive design strategy particularly daylighting is effectively used (Mousavi, Khan, & Wah, 2018; Lim, 2014; Mahdavi et al., 2015; Nikpour & Kandar, 2013). Previous studies by Zomorodian et al.(2016), Rena (2017) & G. Lim et al.(2017) show that the effective use of daylighting can lead to a healthy indoor environment, reduce energy consumption, and provide good visual comfort to the residents. In a multi-storey building, typical zones for active human activities should be located about 5m deep from the window wall or top floor of a building with skylight (Leslie, 2003).

Daylight in building includes direct sunlight, diffused skylight and light reflected from the elements surrounding them. Sunlight is the light that comes directly from the sun while light of the day is the combination of all direct or indirect sunlight during the daytime. Sunlight is very bright and hot which causes thermal and visual discomfort. However, daylight is more gentle and provides illumination without any unwanted effects of sunlight (Modaresnezhad, 2016). Daylighting depends on two strategies: to maximize use of diffuse daylight penetration and to minimize direct sunlight beam. Typically, global daylight illuminance in tropical climates can reach up to 120,000 kx and can lead to thermal and visual discomfort (Y. Lim, 2014)

With the use of several types of architectural elements such as windows, skylights, roof monitors and clerestories can further extend daylight into the space. There are three daylighting zones: primary side-lighting, secondary side-lighting, and top lighting zones. Primary and secondary side-lighting zones are illuminated by windows, while top lighting zones are illuminated by skylights, roof monitor and clerestories. According to Schumann et al. (2013), a side-lighting strategy (vertical windows) provides natural light and views, which includes the distance from the door to the head of a window to determine how far sufficient and beneficial daylight comes into the space. The primary sidelit daylight zone is a daylit area directly adjacent to one or more windows and it is one window head height deep into the area. The secondary sidelit daylight zone is an area not directly adjacent to a window that still receives some daylight and is calculated by two window head heights deep into the area.

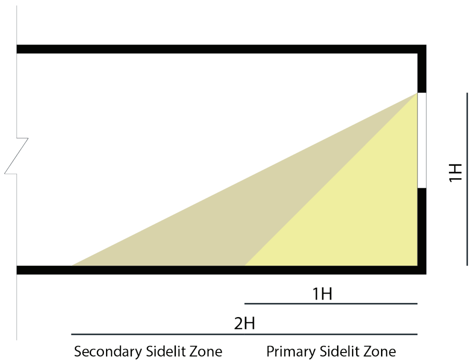


Figure 1: The Primary and Secondary Daylight Zone
Source: Modaresnezhad, Malak, (2016)

According to the New Buildings Institute (2015), the height, orientations, and materiality of partitions (reflective surfaces of partitions) can affect the amount of transferred daylight from windows and the lighting conditions of space. Higher partitions that are greater than 48" should be used perpendicularly to the perimeter glazing which will provide privacy, a sense of enclosure, and unobstruction of the daylight direction. The above finding was supported by a study conducted by Modaresnezhad (2016) on a comparative study of workstation partition in an open plan office. The result shows that partition material, height, orientation and orientation have a robust impact on daylight sufficiency and the risk of daylight excessiveness.

Static daylight performance metrics have certain limitations because they are based on an overcast sky condition (Reinhart, 2006 & Leslie et. al 2012). In contrary, Dynamic Daylight Metric are attained by climate-based daylight modelling (CBDM). According to J. Mardaljevic & L. Heschong (2009) luminous quantities can be predicted using CBDM while the sky conditions are derived from datasets from meteorological stations. Therefore, to enhance the validity of daylighting assessment, the application of Dynamic daylight metrics such as Useful Daylight Illuminance(UDI) is vital because both location and orientation are being considered. The UDI metrics states the percentage of occupied hours when the illuminance value in the range of specific illuminance bin. The original formulation was introduced by Mardaljevic & Nabil (2006) and they suggested three illuminance bins to be considered for the illuminance; lower than 100 lux (insufficient daylight), between 100 and 2000 lux (appropriate daylight) and higher than 2000 lux (potential glare).

In recent years, quite a few daylighting simulations programs that allow for the climate-based daylight analysis have become commercially available in the market. One of the prominent program is called DIVA for Rhino. DIVA uses RADIANCE and Daysim as its simulation engine which have been well validated in the industry (Jakubiec, 2015). This research uses DIVA-for-Rhino as the lighting simulation software. DIVA, developed by the Graduate School of Design at Harvard University, uses TMY3 weather data to calculate climate-based results, as opposed to the conventional Daylight Factor approach that only involves overcast sky condition. DIVA-for-Rhino is a Rhinoceros plug-in for accurate lighting evaluations and also the development of glare analysis and energy consumption metrics. DIVA-for-Rhino uses RADIANCE and DAYSIM as its simulation engine which have been well validated in the industry (Jakubiec, 2012). RADIANCE is an open source lighting engine and due to its free feature, many daylighting programs have been developed based on RADIANCE. Moreover, DAYSIM was generated based on RADIANCE for climate-based simulation.

As the number of students increases, the number of student accommodation will also be in high demand. Currently, there are seven new student residential buildings in a Malaysian polytechnic that use the internal partition layout. The selected building is a new student residential building located in Ipoh, which is designed with internal partitions. This study aims to investigate the impact of several internal partition layout on annual indoor daylighting performance in the residential rooms of students as a sustainable approach to energy saving in a tropical climate. The results of this study will facilitate designers and architects to make better design decisions for the new student residential buildings. The impact and advantages of internal partitions can be accessed in order to provide sufficient daylight and visual comfort. Although the end users are unable to retrofit those fixed parameters after occupancy in their houses, they can alter the interior design parameters, such as the internal shading device, furniture, and so forth (Mousavi et al., 2018). Any improvement in the existing building can be done as it only involves the internal partitions without affecting the structure of the building.

METHODOLOGY

The methodology was carried out in four phases (figure 2). The first phase is the data collected from field experiment. Then, verification and validation process are done which included 3D model of the case study room similar to the real one used in a student residential building. The results of the field measurement are compared with those of the simulations. The second phase is the data analysis which involves the process of simulating five types of internal partition layout using daylight simulation. The third phase is result and finding to analyse the overall results based on annual climate-based daylight metric recomended by MS 2680:2017 for residential building which is Useful Daylight Illuminance (UDI) during the occupied hour (8.00A.M. -6.00P.M./10 hours). Finally, the fourth phase is the discussion, conclusion and recommendation in improving the illumination level inside the room. MS 2680:2017 does not specify the target percentage of UDI to be achieved. Therefore, this research assumed that UDI100-2000lux is higher than 50% or higher than the existing condition which is the target for evaluation criteria as decribed by Dalla Mora et al.(2018) and Berardi & Anaraki (2015).

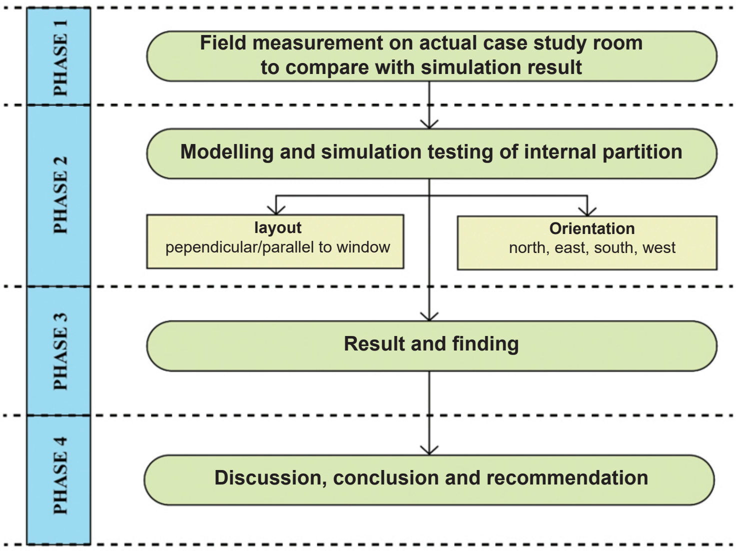


Figure 2: Research Methodology Flowchart
Source: Author

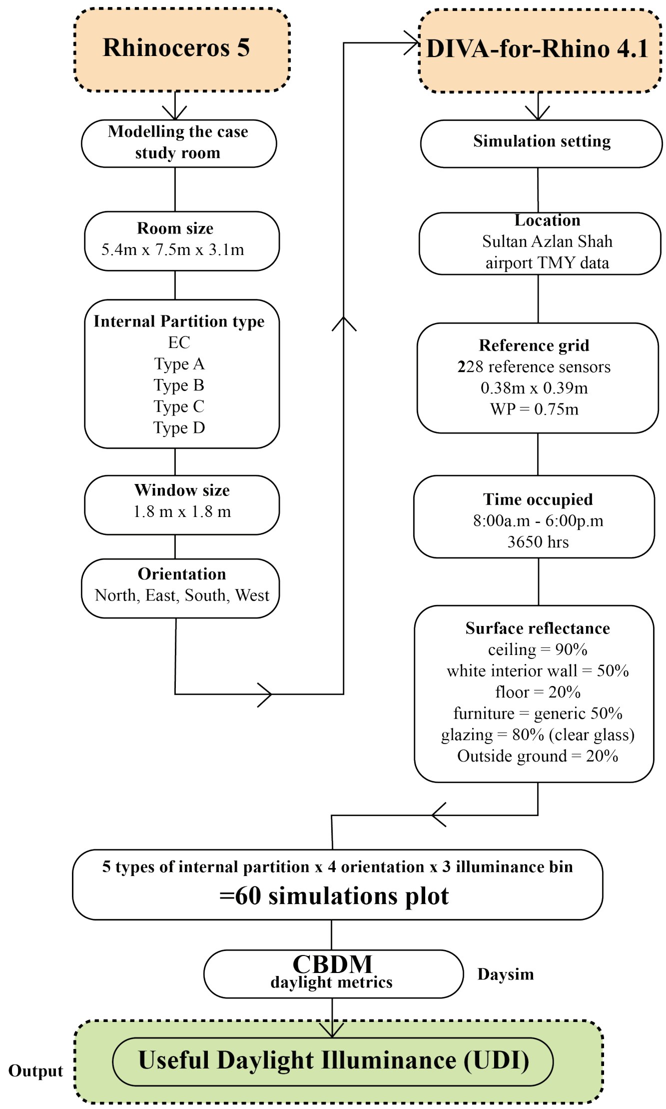


Figure 3: Flowchart of Simulation Experiment
Source: Author

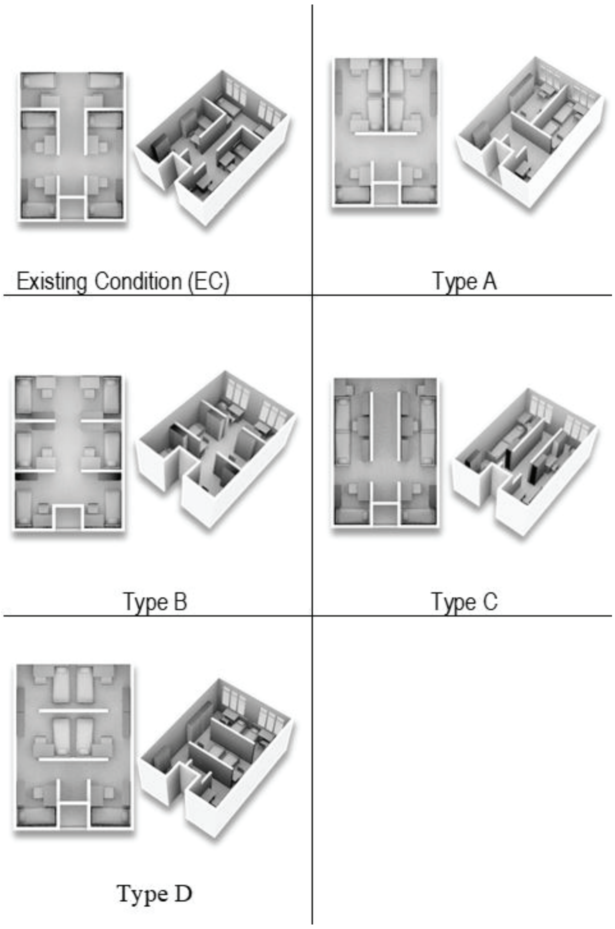


Figure 4: The Existing Condition of the Partition Inside a Room and Proposed Types of Internal Partition Layout to be tested using Simulation Software
Source: Author

Table 1: The Internal Partition Design Description

Type	Description
EC	Existing condition internal partition with 2.1 m height. The partition layout is the combination of parallel and perpendicular to a window that can accommodate six students at one time.
Type A	Internal partition with 2.1 m height. The partition layout is the combination of parallel and perpen-dicular to a window that can accommodate six students at one time.
Type B	Internal partition with 2.1 m height. The partition layout parallel to a window that can accommo-date six students at one time.
Type C	Internal partition with 2.1 m height. The partition layout perpendicular to a window that can ac-commodate six students at one time
Type D	Internal partition with 2.1 m height. The partition layout parallel to a window that can accommo-date six students at one time.

Source: Author

Field Measurement

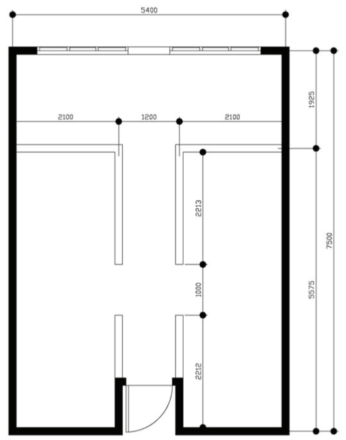
To ensure the accuracy of the simulation results, an actual field experiment should be conducted under the Malaysian tropical sky. If there were any inconsistencies when compared with the measured data, several input parameters were tuned (Al-Tamimi & Fadzil, 2011; Mousavi et al., 2018). This process is usually known as the calibration of the simulation model. In order to calibrate, the building simulation results need to be compared with fieldwork data. Due to the security reason, field measurement was done during semester break from 18th until 22nd May 2018.

Specification of the Case Study Room

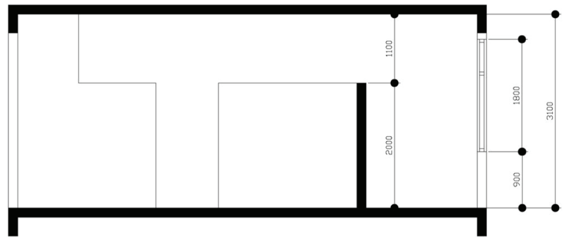
The case study room was located at Politeknik Ungku Omar, Ipoh, Perak (4.57 N/ 101.10 W) Perak facing North East. The window has a head height of 2.7 m, and the sill is at 0.9 m, thus making the height of the window at 1.8 m. The case study room was modelled using Rhinoceros 5.0 programme with the same specification as shown in Figure 7 (a-b) that shows the geometry of the room.

Experiment Setting

As shown in Figure 4, six (6) positions of reference point were placed at the working plane height (75cm) in the case study room to calculate the work plane illuminance (WPI) by using lux meter. The measurement was carried out from 9.00 am to 4.00 pm during a five-day period where the rooms had been exposed without any curtain (Table 2). Based on an indoor daylighting experiment conducted by Mousavi et al., (2018), the time interval of taking measurement was set every five minutes by using data logger. However, in this experiment, the time interval of taking the measurement was set at 15 minutes because it was impractical to set the time for every five minutes when using the lux meter. Mousavi et al. (2018) also set the simulation time interval at one hour because it is time consuming to simulate every five minutes.



(a)



(b)

Figure 5: Plan (a) and Section (b) of the Case Study Room
Source: Author

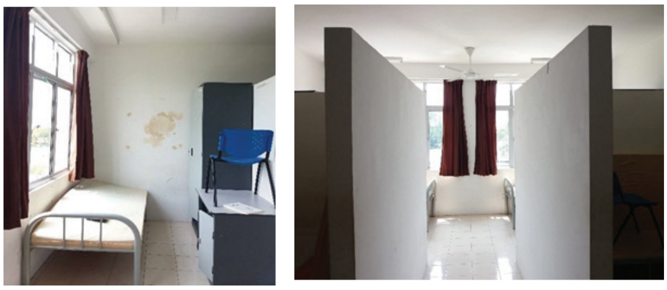


Figure 6: Existing Condition of the Case Study Room
Source: Author

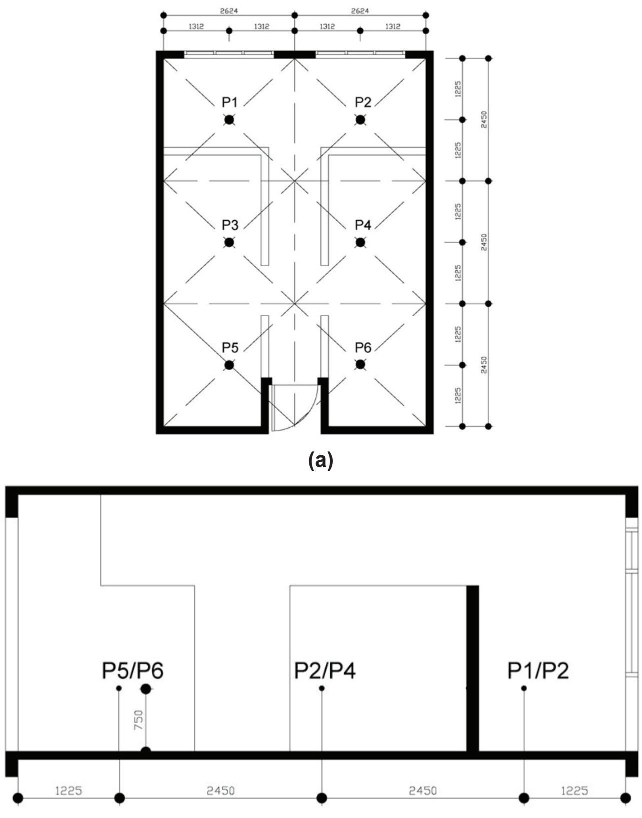


Figure 7: Plan (a) and Section (b) of the Reference Point Location in the Case Study Room
Source: Author

Some daylighting performance indicators were used in this study for the validation exercise of daylighting performance in Radiance DIVA-for-Rhino under the Malaysian tropical climate. WPI was employed to compare the measured illuminance values with the simulated ones at six internal positions. However, it is questionable to use CIE intermediate sky types, which are used in the radiance-based software. The reason is that the value of outdoor illuminance in the tropical climate of Malaysia could be as high as 120000 lux, whereas simulated value was up to 20000 lux under the CIE sky (Lim et al., 2017). Therefore, for the significance of this study, the illuminance value was derived from Ipoh Typical Meteorological Year (TMY) data value in the proposed simulated rooms under a tropical sky. Table 3 shows the mean value difference between CIE intermediate sky and tropical sky under TMY weather data in Diva for Rhino.

Table 2: Summary of the Measurement in the Case Study Room

Day	Date	Start Time	End Time	Time interval
1st	May 18 2018	9 A.M.	4 P.M.	15 min (Measured), 1 hour (Simulated)
2nd	May 19 2018	9 A.M.	4 P.M.	15 min (Measured), 1 hour (Simulated
3rd	May 20 2018	9 A.M.	4 P.M.	15 min (Measured), 1 hour (Simulated)
4th	May 21 2018	9 A.M.	4 P.M.	15 min (Measured), 1 hour (Simulated)
5th	22 May 2018	9 A.M.	4 P.M.	15 min (Measured), 1 hour (Simulated)

Source: Author

Table 3: Mean Value of the Simulated and Global Illuminance Data in Ipoh During Four Days of the Field Measurement

Time	Mean Outdoor Illuminance of CIE intermediate sky (lux)	Mean Outdoor Illuminance taken from Ipoh Typical Meteorological Year (TMY)
9:00 AM	19690	65873
10:00 AM	21793	80810
11:00 AM	20768	88827
12:00 PM	19745	70835
1:00 PM	20119	85299

2:00 PM	21609	73354
3.00 PM	21019	55515
4.00 PM	16612	31784

Source: Author

DIVA-for-Rhino simulation software was used in this study to evaluate daylight performance in the student residential room with internal partition. According to a survey done by Galasiu and Reinhart (2016), nearly 50% among 185 participants from 27 countries chose Radiance-based software from 40 daylight software that was available in the market. Radiance is known to provide a higher level of accuracy in predicting the levels of daylight illuminance compared with several other daylighting software packages. It is helpful in determining whether there is sufficient light to accomplish different activities or otherwise. In this study, DIVA-for-Rhino software is used because of the progressive facilities and accessibility to a comprehensive collection of daylight and visual comfort analysis. The typical configuration of the case study room with four typologies of internal partition layout (Figure 4) in the existing student residential building in Politeknik Ungku Omar, Ipoh, was modelled through Rhinoceros 5 software. The reflectance values of the materials are based on the previous study done by Moazzeni and Ghiabaklou (2016). In order to produce an accurate result, the furniture was also included in the simulation. The most critical parameter is the ambient bounces (ab) amount, which shows the number of daylight radiance reflections. In order to achieve exact results in the modelled case study room, ab is considered to be equalled to 5 (Moazzeni & Ghiabaklou, 2016).

Table 4: Materials Surface Reflectance

Materials Surface	Reflectance Value (%)
Wall	70
Ceiling	90
Floor	20
Glass	Double glazing, 80% light transmission
Furniture	50
Outside ground	20

Source: Moazzeni & Ghiabaklou (2016)

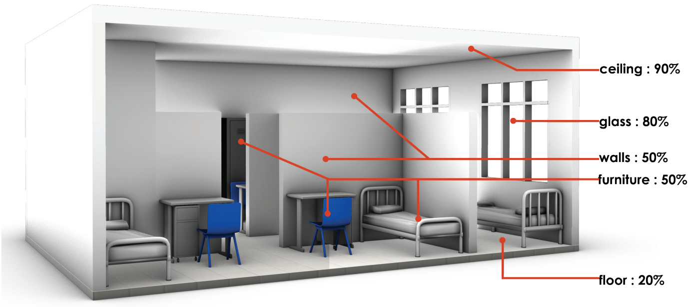


Figure 8: Material Surface Reflectance in the Case Study Room
Source: Author

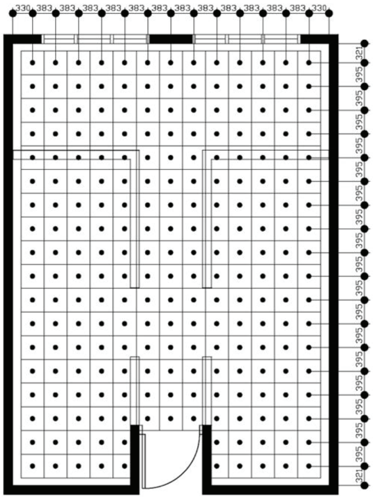
Table 5: The Number of Applied Parameters for Radiance Daylight Simulation

ab (Ambient Bounces)	ad (Ambient Division)	as (Ambient Sampling	aa (Ambient Accuracy)	ar (Ambient Resolution)	dt (Direct Threshold)
5	1000	20	0.1	300	0.1

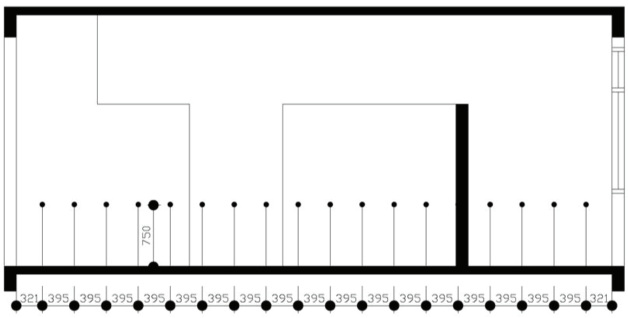
Source: Moazzeni & Ghiabaklou (2016)

Simulation Procedure

Climate Based Daylight Modelling (CBDM) for dynamic daylight metric in the DIVA-for-Rhino programme was simulated to demonstrate the indoor daylight performance for different internal partition conditions. In this experiment, the use of hourly time steps to describe the relevant climate variables as recorded by meteorological stations (Sultan Azlan Shah Airport), allows for understanding the daylight distribution in a space under tropical sky and times of the year. For analyzing daylight, the illuminance grids were placed 0.75m above the floor according to In MS 2680:Energy efficiency and use of renewable energy for residential buildings - Code of practice(2017). There were 228 sensors placed with 0.38 x 0.39 reference grid. (Figure 9).



(a)



(b)

Figure 9: Plan (a) and Section (b) of a Sensor Grid Location in the Case Study Room
Source: Author

Simulation Output

In this experiment, Useful Daylight Illuminance (UDI) was used as a daylight metric. In MS 2680: Energy efficiency and use of renewable energy for residential buildings - Code of practice(2017), the Useful Daylight Illuminance (UDI) is another approach which draws on a range of useful levels. It is defined as the annual occurrence of illuminances across the work plane where all the illuminances are within 100 lux to 2000 lux.

It is a dynamic daylight performance. UDI aims to determine when the daylight levels are 'useful' for the occupants. According to Costanzo et al., (2018), climate-based daylight modelling is potentially more accurate than the Daylight Factor (DF) assessment. It combines the quality of the light assessed during the year which is based on annual weather information and changing conditions, compared to the conventional Daylight Factor approach that only involves overcast sky condition and is assessed in a particular time and fixed conditions. DIVA uses TMY weather data to calculate climate-based results (Moazzeni & Ghiabaklou, 2016). For this study, daylight illuminance in the range of 100-2000 Lux is considered as 'useful' for the occupants, while daylight that is greater than 2000 Lux will cause glare and thermal discomfort. This research assumed reference values for the evaluation of the data obtained by simulations

RESULTS AND DISCUSSIONS

Validation Test of the Case Study Room Under a Tropical Sky

Successful computerized building simulations can be achieved with accurate and reasonable input data from buildings and climate. Several studies suggested that simulated results must be compared with the fieldwork data, and several input parameters affecting the simulation discrepancies should be tuned (Al-Tamimi & Fadzil, 2011).

An average of five days of data for six points from 9.00 A.M. until 4.00 P.M. in a case study room was analyzed and compared to the simulation data. The result shows that the average values between the measured and simulated data are quite similar, as demonstrated in Figure 10.

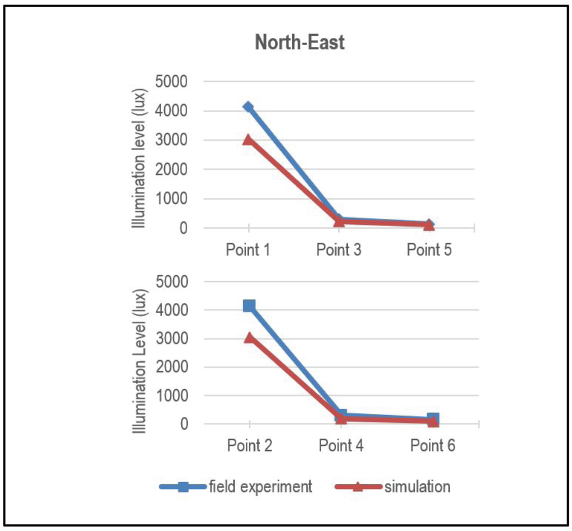


Figure 10: Mean Simulated and Measured Results of the Illumination Level at 6 Points in the Case Study Room from 9.00 a.m. until 4.00 p.m. For Five Days of Measurement
Source: Author

Statistical analysis was used to assess the value of the Pearson correlation for simulated and measured values in the case study room. The analysis revealed that the Pearson correlation coefficient with the value of 0.944 is very close to 1, which indicates that the field measurement data and the simulated data are normally distributed, and there is a strong and linear association between them under the Malaysian tropical sky as shown in Table 6.

Table 6: Pearson Correlation for Simulated and Measured Values Under Malaysian Tropical Sky

Pearson Correlation	Sig. (2-tailed)	N
.944**	0.000	6

***Correlation is significant at the 0.01 level (2-tailed)*

Source: Author

Simulation Results and Discussion

The simulation software simulated and analyzed daylight based on Radiance and Daysim. The discussion was only focusing on the comparison between the existing condition (EC) and the most effective partition for daylight penetration, which is Type C. Type A, B and D demonstrated the ineffective daylight penetration compared to type C, but better than the existing condition for all orientation. The overall data of UDI for all types of partition configuration are shown in Figure 7. Overall, East and West direction recorded higher (100-2000 lux) as compared to North and South direction in all types of internal partition. Excessive daylight and glare issues were also recorded in the East and West direction due to lower altitude of sun throughout the year.

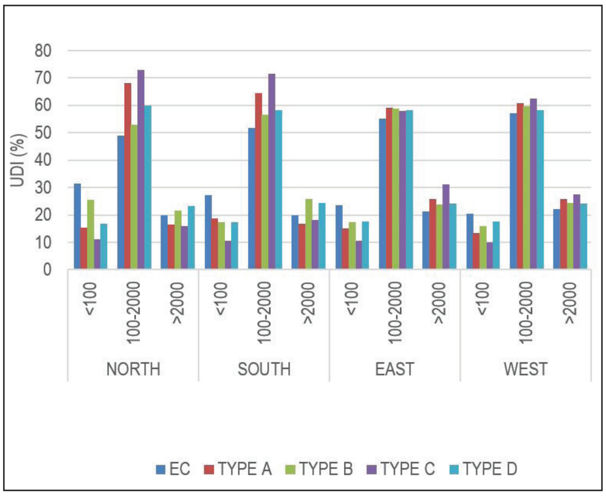


Figure 11: The Overall Data of UDI for all Types of Partition Configuration
Source: Author

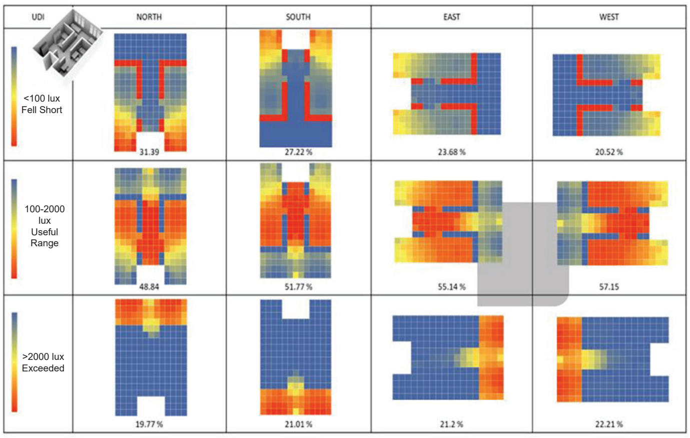


Figure 12: UDI Pattern of Existing Condition (EC) Internal Partition
Source: Author

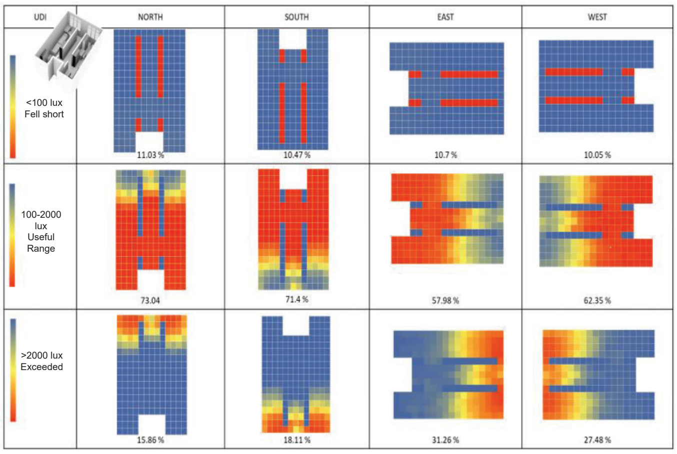


Figure 13: UDI Pattern of Type C Internal Partition
Source: Author

Northern Orientation

As shown in Figure 12, the UDI exceeded (>2000 lux) values were relatively low in Existing Condition (EC) and Type C partition at a location near the window. It shows that the North orientation side has a lower amount of glare than the other orientations. The internal partition Type C recorded the highest percentage of useful daylight (100-2000 lux) and the lowest UDI fell short (<100 lux) due to the positioning of internal partition perpendicular to the window that allows more daylight to enter the room. It is obvious that in the EC type, about 31% of the time during a year the daylighting level is below 100 lux compared to other internal partition types. This is because the parallel side of the internal partition, which is located near the window blocks the daylight from penetrating inside the room. It will increase the dependence on artificial lighting and be very challenging to provide a comfortable visual indoor environment. Therefore, the internal partition needs to be arranged from blocking the daylight, and the partition height needs to be reduced to allow more daylighting.

Southern Orientation

In the southern orientation, UDI exceeded area is almost the same in EC and Type C partition about 21% and 18% respectively. Type C recorded about 71.4% range of useful daylight (100-2000 lux) over the year, but as expected the existing condition type has the highest percentage of below useful range (<100 lux) for about 27.2% as compared to other internal partition types. This is because of the limited amount of daylight penetrates inside the room due to the positioning of internal partition that parallels with the window. The experiment reveals that the existing condition of the internal partition will result in insufficient daylight level in the southern orientation and require modification. Therefore, using the internal partition that parallels to the window is not preferable. The combination of parallel and perpendicular internal partition can be used if the parallel side is located at the back of the room as demonstrated in Type A.

Eastern and Western Orientation

The UDI results in EC and Type C internal partition on the east and west facades recorded nearly the same amount of percentage as the sun movement is symmetrical. As shown in Figure 8 and 9, the area near the window experienced a higher level of glare compared to the north and south orientations. The results reveal that the internal partition Type C has a high percentage of UDI useful range in the east (54.5%) and west (56.5%) respectively. The worst condition of internal partition belongs to EC type with UDI fell short around 23% in both eastern and western orientation. At the east and west side, the amount of sunlight is quite high and can cause disturbing glare in the area near the window. However, by using a combination of window and light shelf that acts as both a light controller and shading might reduce overlit area and increases the daylight distribution.

CONCLUSION

This research was conducted to evaluate the impact of several internal partitions on indoor lighting performance in a student residential building room through annual climate-based daylighting simulation. With the goal of delivering maximum daylight level in the course of the year, the results reveal that the partition layout has a considerable impact on annual daylight performance in four building orientation (north, south, east, west). Based on the findings of the daylight performance analysis of five (5) types of internal partition layouts through simulation, the internal partition that is positioned perpendicular to the window (Type C) has the highest annual daylight sufficiency values, whereas the internal partition that is positioned parallel to the window has the worst annual daylight performance. It is also found that high partitions provide privacy and a sense of enclosure, but at the same time, they block more sunlight. Therefore, the author suggests the best layout is the internal partition in a perpendicular position to the window (type C) as it allows more daylight penetration inside the room than the partition with the parallel position. In addition, reducing the partition height and installing light shelf might improve the daylight level inside the room. Further studies are required to improve the current design in terms of height and materiality, and the impact of furniture layout.

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REFERENCES

Berardi, U., & Anaraki, H. K. (2015). Analysis of the Impacts of Light Shelves on the Useful Daylight Illuminance in Office Buildings in Toronto. *Energy Procedia*, 78, 1793–1798. https://doi.org/10.1016/j.egypro.2015.11.310.

Dalla Mora, T., Leorin, A., Nardo, G., Busatto, N., Peron, F., & Romagnoni, P. (2018). *Daylight Performances in Typical Inner Spaces with Climate-Based Daylight Modeling Approac*h. 4th Building Simulation and Optimization Conference.

Jamaludin, A. A., Inangda, N., Mohd ariffin, A. R., & Hussein, H. (2011). Energy Performance of Three Residential College Buildings in University of Malaya Campus, Kuala Lumpur. *Journal of Design and Built Environment, 9*, 59–73.

Korsavi, S. S., Zomorodian, Z. S., & Tahsildoost, M. (2016). *Visual Comfort Assessment of Daylit and Sunlit Areas: A Longitudinal Field Survey in Classrooms in Kashan, Iran.* Energy and Buildings. https://doi.org/10.1016/j.enbuild.2016.06.091.

Kumar, P. (2014). Evaluation of Thermal Comfort of Naturally Ventilated University Students' Accommodation based on Adaptive Thermal Comfort Model and Occupant Survey in Composite Climate. *International Journal of Architecture, Engineering and Construction, 3*(4), 298–316. https://doi.org/10.7492/IJAEC.2014.024.

Lim, G. H., Hirning, M. B., Keumala, N., & Ghafar, N. A. (2017). Daylight Performance and Uusers' Visual Aappraisal for Green Building Offices in Malaysia. *Energy and Buildings*. https://doi.org/10.1016/j.enbuild.2017.02.028.

Lim, Y. (2014). Dynamic Daylight and Solar Control in Tropical Climate. 11(10), 1766–1772.

Korsavi, S. S., Zomorodian, Z. S., & Tahsildoost, M. (2016). Visual Comfort Assessment of Daylit and Sunlit Areas: A Longitudinal Field Survey in Classrooms in Kashan, Iran. *Energy and Buildings*, 128, 305–318. https://doi.org/10.1016/J.ENBUILD.2016.06.091.

Moazzeni, M. H., & Ghiabaklou, Z. (2016). Investigating the Influence of Light Shelf Geometry Parameters on Daylight Performance and Visual Comfort, a Case Study of Educational Space in Tehran, Iran. *Buildings, 6*(3), 1–16. https://doi.org/10.3390/buildings6030026

Modaresnezhad, M. (2016). *A Comparative Study of Workstation Partitions in an Existing Side?Lit Open Plan Office with Daylight Results Using Annual Climate Based Simulations*. University of North Carolina.

Mousavi, S. M., Khan, T. H., & Wah, L. Y. (2018). *Impact of Furniture Layout on Indoor Daylighting Performance in Existing Residential Buildings in Malaysia*. 5, 1–13. https://doi.org/10.15627/jd.2018.1.

Nabil, A., & Mardaljevic, J. (2006). Useful Daylight Illuminances: A Replacement for Daylight Factors. *Energy and Buildings*. https://doi.org/10.1016/j.enbuild.2006.03.013.

New Buildings Institute. (2015). *Daylighting Pattern Guid*e. Retrieved 19 September, 2019, from http://patternguide.advancedbuildings.net/patterns.

Nikpour, M., Kandar, M. Z., & Roshan, M. (2013). Empirical Validation of IES < VE > Simulation in Term of Daylight in Self- Shading Office Room in Malaysia. *Journal of Basic Applied Science Research,* 3(10), 106–112.

Mardaljevic, J., Heschong, L., & Lee, E. (2009). Daylight Metrics and Energy Savings. *Lighting Research & Technology, 41*(3), 261–283. https://doi.org/10.1177/1477153509339703.