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EXPLORING THE DAYLIGTING PERFORMANCE AT THE STUDENT RESIDENTIAL BUILDING AT POLITEKNIK UNGKU OMAR BY USING INTERNAL PARTITION

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ABSTRACT

The recent global warning problem has a significant impact on architecture design as architecture have been forced to be careful regarding environmental impacts and sustainability. Insufficient natural daylight inside buildings leads to an increase in electrical consumption due to usage of artificial lighting. Hence, the objective of this study is to analyse the impact of daylight illuminance in different internal partition alternatives through climate-based daylighting modelling (CBDM) and compare the value of the target threshold found in the literature. The finding indicates that changing the internal partition layout in a student residential room and installing light shelf generate a robust impact on daylight sufficiency. The study revealed that the highest annual daylight sufficiency values belong to those internal partitions oriented perpendicular to the window with the installation of static light shelf. These improvements could provide a comfortable, productive, and healthy environment for occupants as well as savings in annual energy consumption. The impacts of internal partition as a typical interior design element on indoor daylighting performance in student residential buildings can be accessed. It also provides significant alternatives for architect regarding daylighting design in tropical countries, especially Malaysia.

1. Introduction

The recent global warming problem has a significant impact on architecture design as architects have been forced to be cautious of environmental impacts and sustainability. From an architectural point of view, the way people maintain their safety in a building is a major challenge, particularly when the environment is anticipated to change. Daylighting is a topic of interest that needs to emphasized on nowadays (Garcia-Fernandez & Omar, 2023). Lapisa et al., (2018) has proven that the use of daylighting as a passive design strategy in buildings can save 10% of energy in tropical climates. Daylighting is a technique that involves incorporating natural daylight into the building, through openings to provide adequate indoor lighting to replace electric lighting. Effective use of daylight in buildings can save up more than 50% of electricity (Ahadi et al., 2017). According to Revichandran et al., (2022) universities in Malaysia may be facing an inefficient use of electrical energy and poor energy optimization. There are many potential advantages of using natural daylighting in buildings. If it is adequately controlled and distributed, natural daylighting will contribute to a significant impact, especially in energy consumption, health, and visual comfort. Daylight can have a positive effect on work productivity and well-being as widely acknowledged in previous studies. Besides saving energy, daylight can also provide comfort and a healthy environment for the residents. This study is conducted to compare five types of internal partitions in four orientations (north, south, east, and west) by using Climate Based Daylighting Modelling (CBDM). Annual climate-based metrics, Useful Daylight Autonomy (UDI) as suggested in MS 2680: 2017 Energy Efficiency and Use of Renewable Energy for Residential Buildings - Code of Practice (2017) is used to evaluate daylighting for the year. The UDI approach provides a simple, yet meaningful assessment of daylight and solar penetration together using realistic, climate-based conditions. The impacts of internal partition as a typical interior design element on indoor daylighting performance in student residential buildings can be accessed and provide significant alternatives for architect with regard to daylighting design in tropical countries, especially Malaysia.

Malaysia gets plenty of natural light during the year (Wan Nur Hababi Wan Abdullah, 2020.). Therefore, the use of daylighting as an energy conservation tool is essential to the Malaysian environment. Daylighting is one of the key criteria in monitoring energy consumption in buildings (Galatioto & Beccali, 2016). In recent years, the use of daylighting to conserve energy in buildings in tropical and subtropical regions has become increasingly prominent. Based on Energy Commission, Malaysia Energy Statistic Handbook (2019), Malaysia's overall energy trade in 2017 was expressed by different sectors, such as industrial 28%, commercial & residential 13%, transport 38%, agriculture 1%, and non-energy 20%. Buildings use electricity primarily for lighting, ventilation, heating, and air conditioning as shown in Figure 1. Air conditioning and lighting equipment are perhaps the two most energy-efficient appliances in the buildings.

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. A traditional multi-story residential college building in Universities or Polytechnics has an open space configuration, and students stay in a space with two students (double bed) at one time. The rooms in this new hostel, on the other hand, have a 2-metre internal partition height and a capacity of six students (two students per partition area), resulting in a lower level of lighting within the room.
To make thing worst, students tend to close the blind during the daytime to avoid excessive daylight and glare. In fact, during the day, this situation will increase artificial lighting reliance and energy usage. Hence, this study is carried out to find the impacts of internal partition as a typical interior design element on indoor daylighting performance in student residential buildings as a passive design approach towards energy saving.

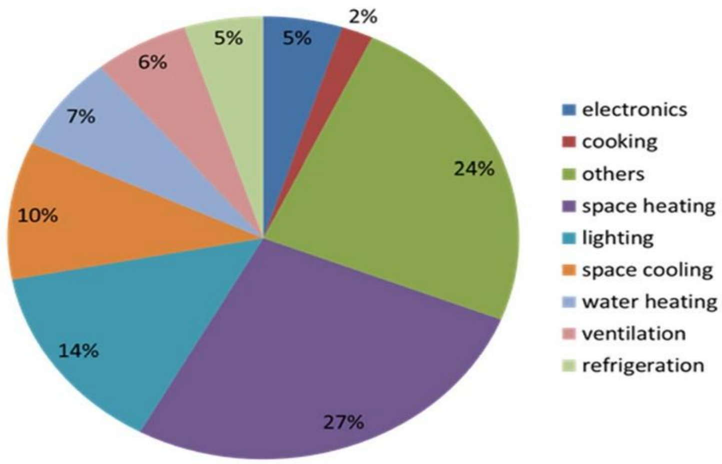

Figure 1. Building Energy Consumption by End Users.

2. Methodology

Polytechnic Ungku Omar at Ipoh, Perak (4.57 N/ 101.10 W) was chosen as the building for this case study because it has the largest student capacity. As shown in Figure 2, the selected block is facing northeast orientation. The building is suitable because it faces a clear view of the sky, and it is not obstructed by other buildings and trees. The chosen building block receives a large amount of sunlight from the field measurement, which makes it suitable to perform field measurement as opposed to a block that has external obstruction influence. Since the external obstructions have a significant effect on daylight availability, the selected room in this case study is located on the ground floor where the amount of sunlight received the lowest value. 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 simulation was performed using Ipoh typical meteorological year (TMY) downloaded from climate.onebuilding.org, a repository of free climate data for building performance simulation.

Figure 2. Aerial view of Politeknik Ungku Omar Student Residential Building.

The amount of daylight that enters the space depends on external obstruction surrounding the building, such as trees and other structure. Figure 3 shows the Typical floor plan of existing condition in a case study room

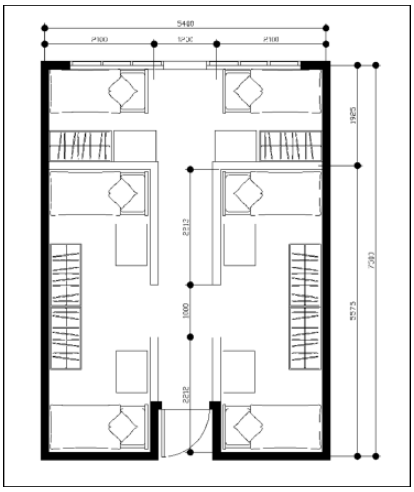

Figure 3. Typical floor plan of existing condition in a case study room.

Before running the daylighting simulation, an actual field measurement should be conducted under the Malaysian tropical sky to ensure the accuracy of the simulation results. Field measurement, as the most reliable method, can be undertaken to evaluate the indoor daylight condition accurately. Several studies suggested that simulated results must be compared with measured data and several input parameters affecting the simulation discrepancies that were tuned (Mousavi et al., 2021). This procedure is usually known as the calibration of the simulation model. To calibrate, the building simulation results need to be compared with fieldwork data. Due to the security and accessibility constraint, field measurement was done during semester break from 18 until 22 May 2018. When determining daylighting levels and solar energy output, sky conditions are crucial. The sky is divided into three categories based on the presence of clouds: clear, partially cloudy, and overcast. For various sky types, many models for calculating global, direct, and diffuse irradiation and illumination were developed based on the values of several climatic factors. A digital camera equipped with a fisheye lens can map at a higher resolution than commercial sky scanners and High Dynamic Range (HDR) images can capture the full sky luminance range (Suárez-García et al., 2020). However, for this research, the equipment was unavailable when the field measurement conducted. Based on observation, the weather outside the classroom was clear and intermediate sky throughout the measurement period.

2.1 Instruments

The instrument used for the indoor field measurement is the EN300:5-in-1 Environmental Meter. The EN300 measures Humidity, Temperature, Air Velocity, Light and Sound. It comes with tripod mount and RS-232 PC interface. Large dual LCD simultaneous display of Temperature and Air Velocity or Relative Humidity (refer Figure 4).

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Figure 4. EN300: 5-in-1 Environmental meter.

As shown in Figure 4, six (6) positions of reference point were placed at the working plane height 0.75m according to MS 2680: 2017 Energy Efficiency and Use of Renewable Energy for Residential Buildings - Code of Practice (2017) in the case study room to calculate the work plane illuminance (WPI) by using 5-in-1 Environmental meter. The points were positioned evenly to get a better measurement reading. The case study room length is 7.5 metres with 5.4 metres width and 3.1 metres in height. The measurement of the room length, width and height were taken before the measurement was conducted. The weather outside the classroom was clear sky and intermediate sky throughout the measurement period. This was carried out from 9.00mA.M. to 4.00 P.M. during a five-day period where the rooms had been exposed without any curtain. The case study room was empty without students during the measurement, as this study is based only on daylighting performance which do not include student performance. Therefore, all electrical appliances were switched off during the practice and all openings such as window and doors were closed. Refering to indoor daylighting experiment conducted by (Mousavi et al., 2021), the time interval of taking measurement was set every five minutes by using a data logger. However, due to the unavailability of data logger during the 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 portable lux meter.

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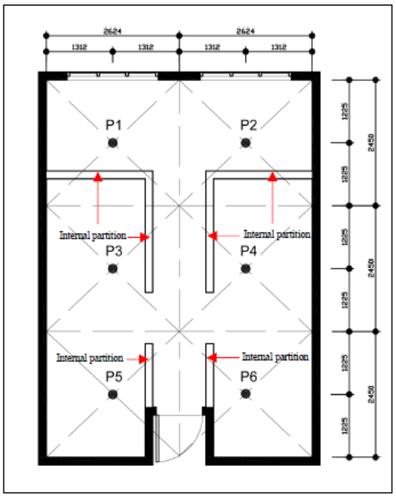
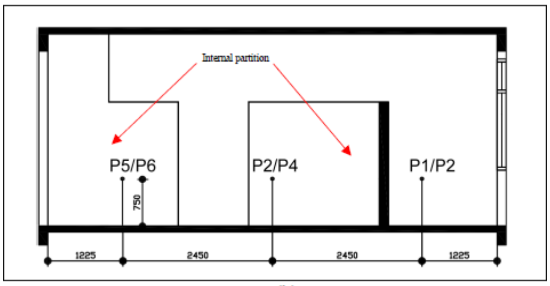


(a)



(b)

Figure 4: Plan (a) and Section (b) showing location of portable lux meter in the case study room.

2.2 Modelling of Existing Condition and Proposed Internal Partition of the Case Study Room

2.2.1 Existing Condition (EC) of a Case Study Room

The existing condition consists of an internal partition with 2-meter height. The internal layout is designed to accommodate six students at one time. Each area is divided with an internal partition to give more privacy and a sense of enclosure with two students per area. The layout combines internal partition parallel and perpendicular to the window. The layout includes moveable furniture to suit student living style. The existing condition focuses more on privacy compared to natural lighting and views.

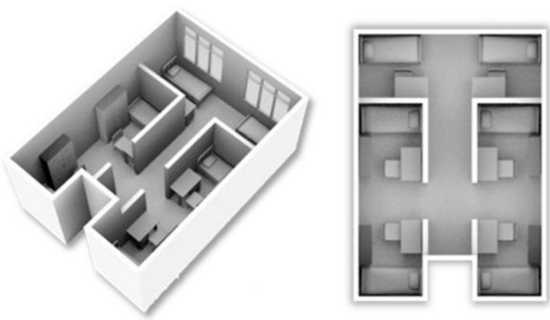


Figure 6. 3D model of existing condition internal partition layout for CBDM

2.2.2 Type A internal partition

Type A internal partition consists of internal partition with 2 m height. The internal layout is designed to accommodate six students at one time. Each area is divided by the internal partition to give more privacy and sense of enclosure with two students per area except at the back of the room with the individual area. The layout combines with internal partition parallel and perpendicular to the window. It includes moveable furniture to suit student living style. Type A emphasized more on natural lighting and views.

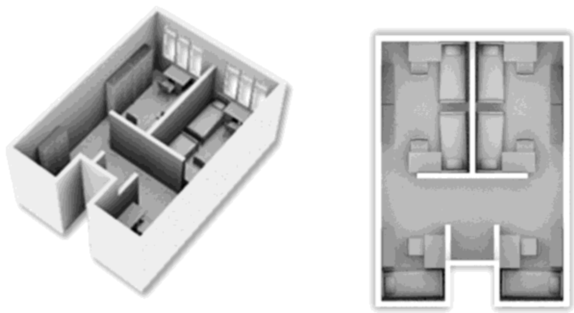


Figure 7. 3D model of Type A internal partition layout for CBDM

2.2.3 Type B internal partition

Type B internal partition consists of internal partition with 2 m height. The internal layout is designed to accommodate six students at one time. Each area is divided by an internal partition

to give more privacy and a sense of enclosure with two students per area. The layout combines with internal partition parallel and perpendicular to the window. It includes movable furniture to suit student living style. Type A emphasized more privacy but at the same time it allows daylighting to enter**.**

Figure 8. 3D model Type B internal partition layout for CBDM

2.2.4 Type C internal partition

Type C internal partition consists of internal partition with 2 m height. The internal layout is designed to accommodate six students at one time. Each area is divided with an internal partition to give more privacy and a sense of enclosure with three students. The layout is designed with an internal partition perpendicular to the window. It includes moveable furniture to suit student living style. Type C emphasized more on natural lighting and views. The student can still feel a sense of privacy with three students per area and it provides more flexible space.

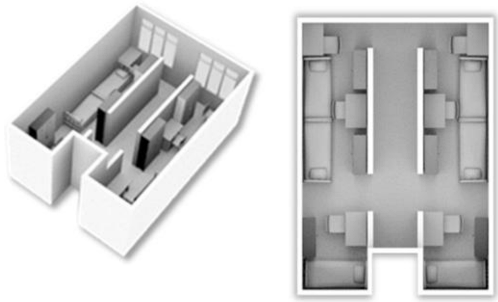


Figure 9. 3D model of Type C internal partition layout for CBDM

2.2.5 Type D internal partition

Type D internal partition consists of internal partition with 2 m height. The internal layout is designed to accommodate six students at one time. The layout is designed with an internal partition parallel to the window. Each area is divided with an internal partition to give more privacy and a sense of enclosure with two students except at the back of the room with the separate area. The layout includes moveable furniture to suit student living style. Type D emphasizes privacy but at the same time allows daylighting to come in.

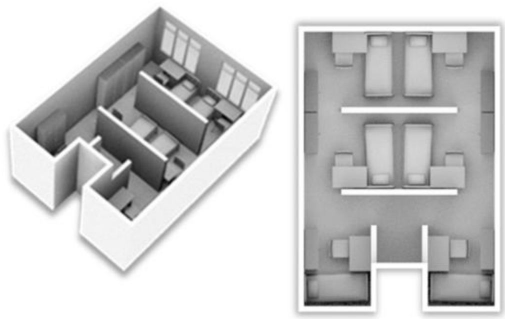


Figure 10. 3D model Type D internal partition layout for CBDM

2.3 Simulation Output

In this research, Useful Daylight Illuminance (UDI) was used as a daylight metric. In MS 2680:2017 for residential building, 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 involves only overcast sky condition and is assessed in a particular time and fixed conditions DIVA uses TMY weather data to calculate climate-based results. 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. Many different results are found in the relevant literature on illuminance optimal values. MS 2680:2017 does not specify the target percentage of UDI to be achieved. Therefore, this research assumes that useful UDI (100-2000 lux) higher than 50% or higher than the existing condition is the target for evaluation criteria as described by (Costanzo et al., 2018).

3. Results from preliminary study for five days measurement on the case study rooms

The field measurement in this study was conducted in five days with a sunny day and intermediate sky. To access the level of daylighting in the case study room, the illuminance data were compared with the international and local illumination standards. The standards are established by the Illuminating Engineering Society (IES) and standards and Industrial Research Institute of Malaysia (SIRIM) with MS 2680: 2017 Energy efficiency and use of renewable energy for residential buildings Code of practice, 2017.

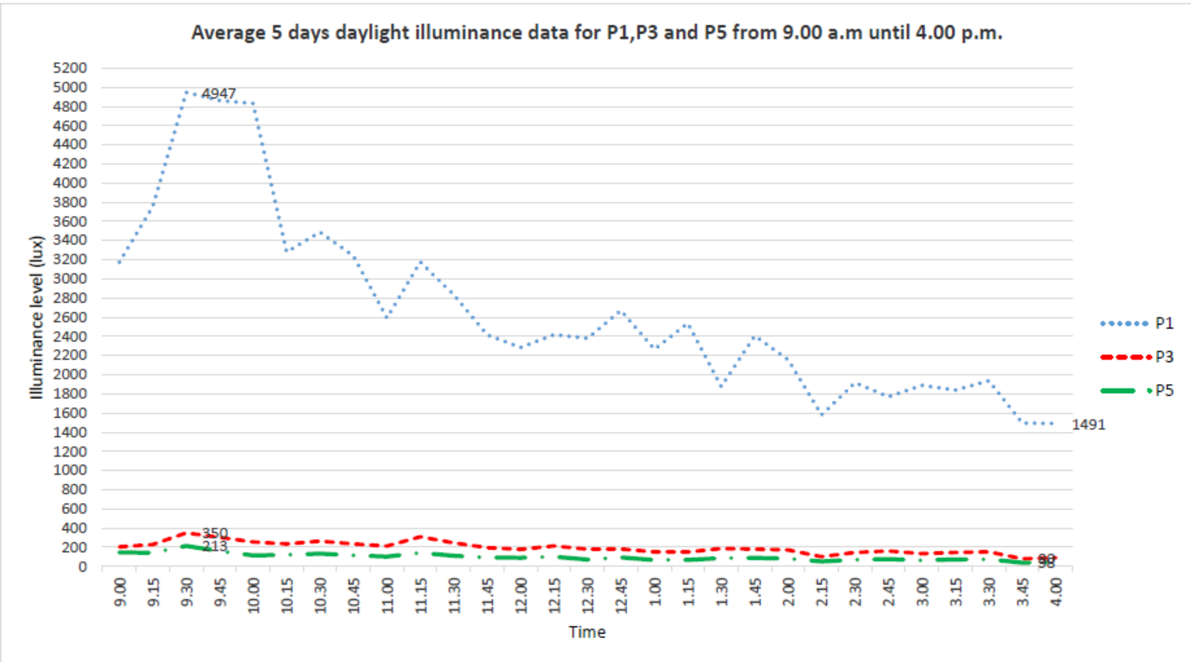


Figure 11. Average 5 days illuminance data for Row 1 from 9.00 a.m. until 4.00p.m

Figure 11 shows the average value of indoor illuminance level for five (5) days in the case study room at P1, P3 and P5. For P1, the highest illuminance level was recorded at 4947 lux at 9.30 a.m. which exceeded the useful daylight illuminance (UDI). Daylight illuminances higher than 2000 lux are likely to produce visual or thermal discomfort, or both. The lowest value was recorded at 1491lux at 4.00 p.m. Even though the lowest illuminance value for P1 considered useful to the illumination of the space, it still exceeded the recommended value of the bedroom. Meanwhile for P3 the highest value was recorded at 350 lux at 9.30 a.m. and the lowest value was at 38 lux at 3.45 p.m. From the graph, it was clearly stated that the daylight illuminance level for P5 was always lower than P3 and P1. Based on figure 4.2, the adequacies of daylight in the selected case study room have fulfilled the minimum requirement for living room (200 lux) and bedroom (180 lux) but not for casual reading (400 lux) and table task work (300 lux) most of the daytime. An area at the back of the room recorded low illuminance level due to increased room depth. In general, beyond 6 meters from a window, the area can be considered as 'partially daylit' which means the area could still be daylit, but it may have to rely on artificial light for a considerable period. The results show that only the side lit room has the effectively illuminating areas that are located near the window. Areas located away from the window experienced low daylight level and the situation worsened when internal partition was used.

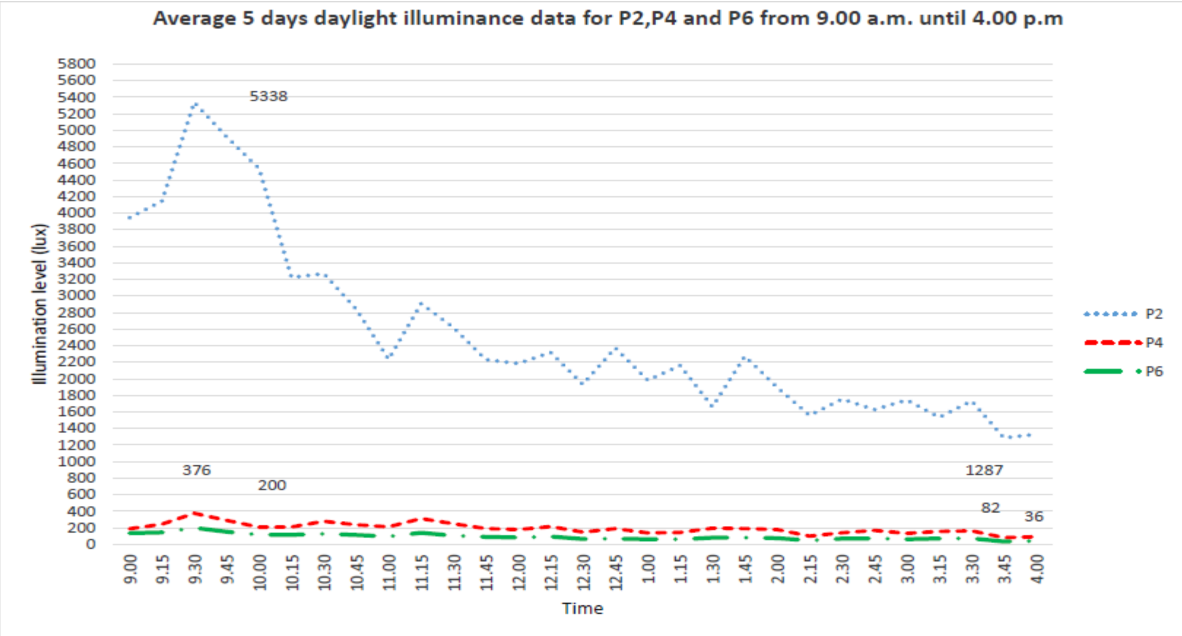


Figure 12. Average 5 days illuminance data for Row 2 from 9.00 a.m. until 4.00 pm

Figure 12 shows the average value of indoor illuminance level for five (5) days in the case study room at P2, P4 and P6. For P1, the highest illuminance level was recorded at 5338 lux at 9.30 a.m. which exceeded the useful range. Daylight illuminances higher than 2000 lux are likely to produce visual or thermal discomfort, or both. The lowest value was recorded at 1287 lux at 3.45 p.m. Even though the lowest illuminance value for P2 was considered useful to the illumination of the space, it still exceeded the recommended value of the bedroom. Meanwhile for P6 the highest value recorded at 200 lux at 9.30 a.m. and the lowest value was at 36 lux at 3.45 p.m. From the graph, it was clearly stated that the daylight illuminance level for P6 was always lower than P4 and P2. Based on figure 4.4, the adequacies of daylight in the selected case study room have fulfilled the minimum requirement for living room (200 lux) and bedroom (180 lux) but not for casual reading (400 lux) and table task work (300 lux) most of the daytime. An area at the back of the room recorded low illuminance level due to increased room depth. In general, beyond 6 meters from a window, the area can be considered as 'partially daylit' which means the area could still be daylit, but it may have to rely on artificial light for a considerable period (Sadin et al., 2014). The results show in the side lit room only effectively illuminating areas that are located near the window. Areas located away from the window experienced low daylight level and the situation worsened when internal partition was used.

3.1 Simulation Output

3.1.1 Existing Condition (EC)

Simulation result based on the existing condition (EC) shows lower than threshold value percentage at least 50% of the time/year of useful UDI (100-2000 lux) in all directions and scenario, as shown in Figure 13. The internal partition was parallel with the window position, causing daylight to be blocked at the front of the room. In scenario A, East and West directions recorded higher useful UDI (100-2000 lux) percentage with 44.17% and 45.84% respectively as compared to the North and South direction with 38.62% and 41.72% respectively. Scenario B shows the opposite pattern with east and west direction recorded lower useful UDI(100-2000 lux) percentage with 41.56% and 41.27% respectively as compared to the North and South direction with 44.23% and 48.83% respectively. The result also shows that in type EC, an area near the window had a percentage of UDI excessive (> 2000 lux) higher in scenario A (from 16.86% to 18.22%) as compared to scenario B (from 9.44% to 9.66%). Excessive daylight and glare issues were also recorded in the East and West directions due to lower altitude of the sun throughout the year. Overall, Rooms located at scenario B did not experience sufficient daylight because of the obstruction from another building and had a lower useful UDI percentage value compared to scenario A.

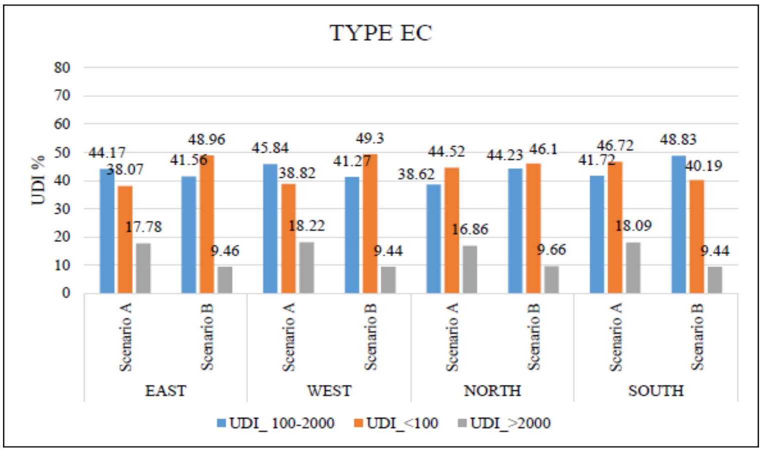


Figure 13. UDI result for EC type

3.1.2 Type A

Based on figure 14, the daylight performance of a student residential room with internal partition was expressed in terms of their Useful Daylight Illumination (UDI) distributions. Simulation result based on type A shows useful UDI (100-2000 lux) percentage demonstrated higher than threshold value percentage (at least 50% of the time/year) in all directions and scenarios. The daylighting performance was improved in type A as compared to type EC. It can be reasoned that the internal partition layout perpendicular to the window greatly influenced the daylighting availability. The simulation results reveal with Type A, the useful UDI (100-2000 lux) value in the North and South orientation received considerably enough daylight internal partition in both scenarios (from 59.94% to 69.16%). However, the simulated results in East and West side of the building showed lower useful UDI (100-2000 lux) percentage values (from 59.94% to 61.82%) in both scenarios because of high UDI exceeded (>2000 lux) in these orientations as compared to North and south (from 67.8% to 69.16%). As expected in scenario A, the area at the back of the room experienced UDI fell short (<100 lux) especially in all directions (from 15.90% to 19.15%), while in scenario B recorded higher value in all directions (from 27.75% to 32.16%). This result revealed that area at the back of the room needs to be equipped with artificial lighting during daytime especially in scenario B.

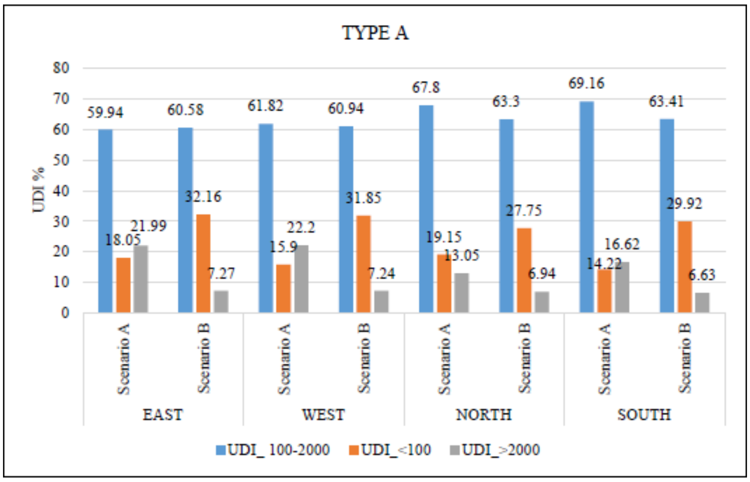


Figure 14. UDI value for type A

3.1.3 Type B

Looking at UDI plots in figure 15, implementing type B layout brings more daylight into the room when useful UDI (100-2000 lux) percentage results demonstrated higher than threshold value percentage at least 50% of the time/year in all direction and scenarios. Useful UDI (100-2000 lux) results using type B internal partition causes sufficient daylight to enter the space in north and south direction in both scenarios (from 56.31% to 59.89%) while useful UDI (100-

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2000 lux) values on the east and west recorded almost in a similar range with north and south orientation (from 54.89% to 59.01%) in both scenarios. In other words, type B internal partition layout does not have a considerable impact on daylight availability because the useful UDI (100-2000 lux) result shows an identical pattern in all orientation and scenarios. Comparing UDI exceeded value (>2000 lux), the risk of excessive sunlight exposure in scenario A is lower in those partitions in scenario B because of the external obstruction in all building orientation. Again, Type B internal partition is better than the existing condition (EC) when useful UDI demonstrated higher than threshold value percentage. However, area at the back of the room experienced UDI fell short (<100 lux) in all direction in scenario A (from 18.62% to 25.41%). The situation getting worst in scenario B when the UDI fell short results is higher (from 32.20% to 35.88%) and need to supply with artificial lighting during daytime.

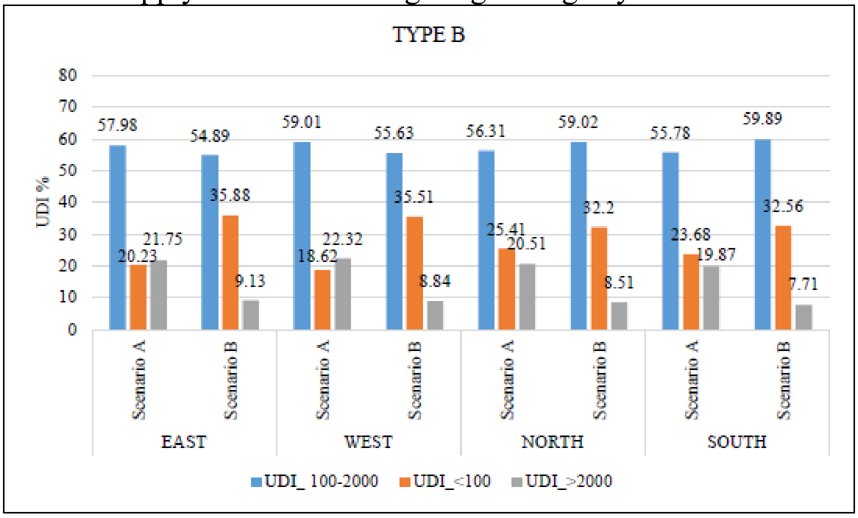

Figure 15. Type B UDI results

3.1.4 Type C

The daylight availability and excessiveness in term of UDI percentage based on type C internal partition were calculated through simulation and plotted in Figure 16. The results indicated that Type C partition layout is better than existing condition (EC) and considerably allows a high amount of daylight entering the space in different orientations (north, south, east, west) and scenarios (scenario A and scenario B). This means that a large portion of the floor area exceeded higher than a threshold value for more than 50% of useful UDI (100-2000 lux) of annual occupied hours. In type C, the highest annual daylight sufficiency values were recorded for north and south orientation (around 70%) as it was expected by changing the partition layout in a perpendicular direction to window, the amount of daylight that enters the space were increased. Regarding UDI exceeded (>2000 lux) in scenario A, values recorded on the east and west orientation were higher (around 20%) than North and south orientation (from 12% to 15%). However, the UDI exceeded in scenario B show less sensitivity because of external obstruction that blocks sunlight from entering the building in all orientation (around 7%). The plots reveal that in scenario A, UDI fell short (<100 lux) is relatively low in east and west

(11.09% to 9.67%). In comparison, UDI fell short (<100 lux) in scenario B considerably high in east and west (28.24% and 27.76% respectively) and need attention to supply with artificial lighting.

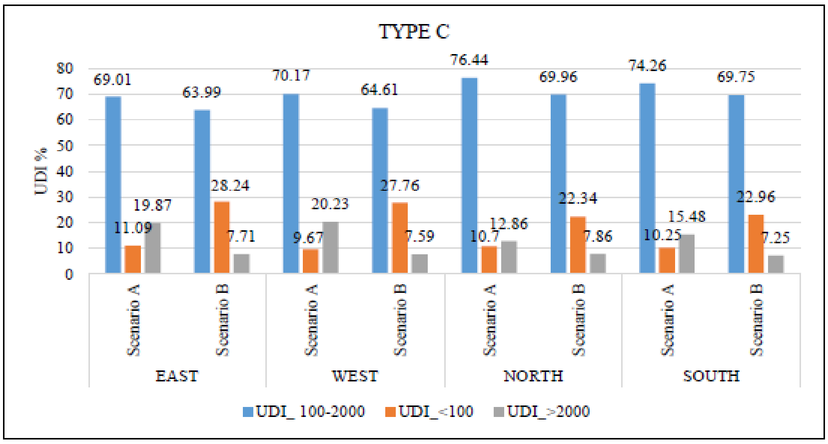

Figure 16. Type C UDI results

3.1.5 Type D

An annual simulation was also run based upon type D internal partition and results are plotted in Figures 17. Looking at the UDI results, using partition oriented parallel to the window causes less daylight to enter the room. However, type D partition still performed better than the existing condition (EC). Useful UDI (100-2000 lux) percentage result reveals that the highest amount of annual daylight sufficiency in scenario A in the same range in all directions (from 44.57% to 52.08%). To make the situation worst, useful UDI in scenario B recorded below the threshold value in all direction (from 45% to 49%). The UDI exceeded (>2000 lux) in scenario A recorded on the east and west side of the building was considerably high (19.22% and 20.44%respectively) as compared to north and south side (18.02% and 17.92% respectively). As it was expected, scenario B recorded lower value of UDI exceeded in all direction, yet the value is almost in the same range (from 9.51% to 9.65%) due to the external obstruction from another block. Another analysis of the UDI fell-short (<100 lux) based upon type D in scenario A, results showed that north and south orientation recorded high value (34.79% and 30.9% respectively) as compared to the east and west direction (28.33% and 27.45% respectively). On the other hand, as opposed to scenario B, UDI fell-short in all direction recorded higher than scenario A (from 41.38% to 45.71%). This reveals that room with type D partition needs to be supplied with artificial lighting during daytime.

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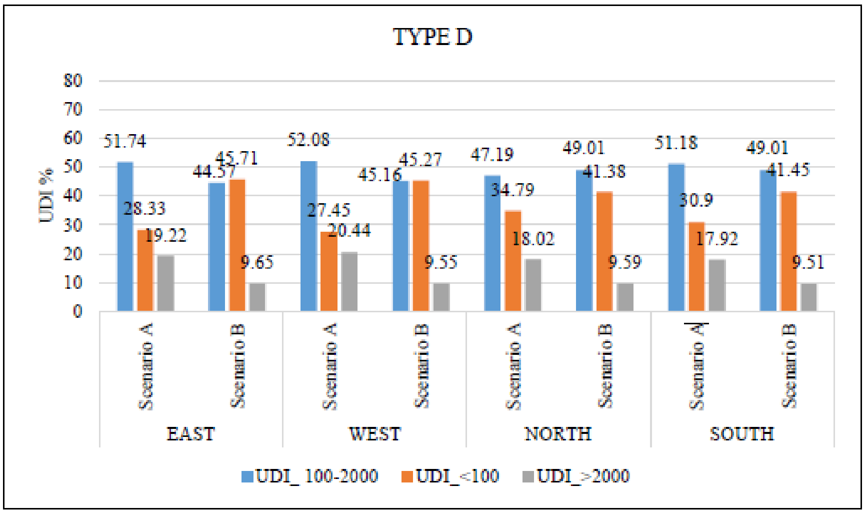

Figure 17. Type D UDI results

4. Discussion

Overall, the result reveal that building orientation, partition layout and external condition have a robust impact on the amount of daylight received. All proposed internal partitions perform better than EC type in both scenarios. The highest useful UDI value belongs to type C followed by type A, type B and type D. The result also shows useful UDI value that was reported high in the north and south compared to east and west orientation in all internal partitions based on perpendicular to window type (type C and type A). This scenario happens due to the high UDI exceeded value recorded in the east and west direction. As expected, new model performs well when the useful UDI value reported almost the same range with type C. This shows that in the new model, by integrating light shelf, the daylighting quality inside the room has improved. This is supported by the finding from that by adding light shelves in all cases, a more uniform and deeper penetration of good daylight become possible.

When comparing UDI exceeded value at all proposed types in all directions and scenarios, the risk of excessive sunlight exposure is slightly higher to those partition-oriented perpendiculars and has more distance from the window (type A, B and type C). In scenario A, east and west façade has more sensitivity in term of direct sunlight and need shading to control glare which may cause discomfort. As expected, UDI exceeded at the area located in scenario B are relatively low (below 10%) and does not require shading element. To reduce the risk of excessive sunlight exposure, the new model is proposed with light shelve as a shading element. It is proven when the new model recorded the lowest UDI and it exceeded among all internal partitions.

The results revealed that the existing condition (EC) showed poor useful UDI results when all orientation and scenarios did not exceed the threshold value. In scenario A, partition layout considerably impacted annual daylight performance depending on direction. It can be concluded that type C and type A let more daylight came in the study rooms when the floor area exceeded more than the threshold value (useful UDI 100- 2000 lux higher than 50%) especially in east and west facade. They provided more daylight than other partition types, yet increased the risk of excessive daylight and glare. UDI exceeded value were reported higher in type A, B and C due to the partition-oriented perpendiculars and more distance from the window. Based on this finding the new model is proposed with the light shelves to act as shading element and to provide uniform daylight distribution.

Relatively, high UDI exceeded reported high on the east and west facade because of direct beam of sunlight into the room, causing intense glare during afternoon. Therefore, shading elements such as light shelves are necessary to block the excessive daylight and to provide more uniform daylight distribution. From the results, low UDI fell short is recorded in type A and type C. This indicates that type A and type C caused a low daylight quantity as they only occurred beyond 6 meters at the back area of the room and artificial lighting must be supplied. While type B and type D provide privacy and sense of enclosure yet considerably blocked the incoming daylight because the partition was oriented parallel to the window. This finding is very useful and supported by the UDI data. Hence, proposed new model can provide more daylight distribution as well as to block excessive daylight and glare.

5. Conclusion

The second phase of the experiment in this research which was the preliminary study involving field measurement to collect the data of the case study room. The results show that in the side lit room was the only effectively illuminating areas that were located near the window. Areas located away from the window experienced low daylight level and the situation worsened when internal partition is used. The third phase of this study is to analyse the overall results based on annual climate-based daylight metric recommended by MS 2680:2017 for a residential building during the occupied hour (8.00 A.M. -6.00 P.M./10 hours). The results and finding are concluded as follows:

- Existing condition (EC) type showed poor useful UDI results when all orientation and scenarios did not exceed the targeted threshold value. This result revealed that EC type need improvement especially in area located at the internal partition.
- Type A, B and C let more daylight came in the study rooms but at the same time increased the risk of excessive daylight and glare due to the internal partition-oriented perpendiculars and located more distant from the window.
- Type B and type D provide privacy and sense of enclosure yet considerably blocked the incoming daylight because the partition was oriented parallel to the window and not favourable to use.
- External obstruction from another block decreased the daylight availability during the course of the day and year in scenario B.
- Type A is the most suitable internal partition in term of providing high privacy and sufficient daylight level while Type C lack of privacy.

As a conclusion, the study revealed that the highest annual daylight sufficiency values belong to those internal partitions oriented perpendicular to the window. Based on the simulation results, the improved new model of room typology has increased level of useful UDI and decreased the UDI exceeded. The analysis show that the new model has met the target evaluation criteria with useful UDI higher than 50% or higher than the existing condition. With the implementation of light shelves, the level of UDI exceeded is lower compared to the existing condition. Based on the result of this study, by using the new room typology model with the internal partition mostly perpendicular to the window and incorporating light shelve, there might be a better indoor lighting level annually in the student residential room. In addition, it can save up electrical consumption and improves student productivity and health.

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