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A Stakeholder Perspective in Optimising Daylight in Classroom

Amirul Aiman Rio Hendry [1], Nur IzieAdiana Abidin [1,*], Suzila Mohd [1]

[1] Faculty of Civil Engineering, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

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ABSTRACT

Building daylighting is a desirable energy-saving method compared to the common continuous electrical illumination practice. Natural daylighting is a crucial part for students and educators in performing visual tasks and is very important for their mental health and well-being. Hence, daylight should always be carefully studied since it may offer both visual and thermal comfort, especially in a classroom. This fact explains why there is a constant need to optimize daylight, including its intensity, direction, distribution, and generation of shadow, which have an impact on human physiology and psyche both directly and indirectly These study aims to determine the perspective of daylight implementation in classrooms for student's learning efficiency. The aim is achieved by identifying the important elements for implementation, investigating challenges faced by occupants, and proposing strategies to improve daylighting in classrooms. A questionnaire survey involving 148 stakeholders consisting of green building certified professionals, architects, engineers, and environmental specialists to gather data on important elements, challenges, and strategies. Statistical analysis was performed using the Statistical Package of Social Science (SPSS) to analyse the collected data. It is found that the most crucial element for daylight implementation is sun shading devices (mean = 4.28), which significantly contributes to visual and thermal comfort. However, the potential major challenge that can be encountered is to provide adequate lighting distribution (mean = 4.13) and potential experience of thermal comfort (mean = 4.04). To address this challenge, the recommended strategy is to use zenithal light pipes to improve lighting distribution and at the same time able to control the heat coming. The findings in this study provide insights to drive the adoption of daylighting implementation and promote sustainable development in campus settings.

1. Introduction

Daylighting has become increasingly significant in the design of structures. In recent years, daylight has been shown to boost the morale and productivity of people who work or live indoors. As a result, daylighting provides behavioural, psychological, and physiological advantages over artificial light that aid in improving people's performance and productivity [1].

* *Corresponding author.*
E-mail address: izieadiana@utm.my

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Classrooms are recognised as primary places for the learning activities that take place to include the cognitive processes of students of all ages. In such settings, daylighting is critical for occupant health and well-being by improving indoor environmental quality and lowering energy consumption for electric lighting. Daylighting in the classroom is advantageous from numerous perspectives. Firstly it adds to the aesthetic and physical characteristics of a learning area while also limiting the possible detrimental consequences of prolonged exposure to electric illumination. Secondly, it is closely related to improved student performance and health conditions. However, a lack of or insufficient daylight can cause weariness, tension, circadian disruption, phase shifting, and Seasonal Affective Disorder (SAD) [2]. Tahsildoost & Zomordian [3] further highlighted that aside from energy efficiency, visual comfort for daylighting in educational buildings is a critical issue since it is directly related to students' well-being and learning process. Bian et al. [4] also added that visual needs for classrooms have not been adequately addressed and are relevant to kids' ability to perform well. The visual needs include adequate lighting on the work plane, the absence of glare, and the intelligibility of visual targets.

Other than that, the legibility of visual targets, such as chalk-written letters on the blackboard, is also an important part of judging the light environment quality and is substantially associated with study performance. The presence of light sources within the reflected scene on a surface (e.g., blackboard, whiteboard, or display screen) frequently causes disturbing reflections. Such reflections are unsettling when they produce a high brightness distributed within the backdrop, which sharply diminishes the difference in luminance between visual objectives (e.g., blackboard texts) and the background (e.g., the blank region around the writings). Most blackboards lack an ideal matt surface that reflects incident light in all directions. Partially glossy surfaces do not disperse light as well: they reflect some of it at an angle equal to the angle of incidence in the same way that a mirror does (specular reflection), making disturbing reflections more intense for pupils in a specific region of the classroom. The disruption may also be caused by ambient light, such as artificial light and daylight, reflecting off the chalkboard. As a result, reducing blackboard reflections through proper lighting design and fixture placement is a sound strategy for improving students' visual performance Bian [4].

Therefore, designing educational spaces with daylight is an important issue being highlighted nowadays. The existing literature lacks of comprehensive exploration of stakeholders' perspectives and their role in optimizing daylight in classrooms. While there are numerous studies that address the technical aspects of daylighting, there is a noticeable research gap in understanding the varied perceptions, preferences and challenges faced by stakeholders. Architects and building researchers are constantly challenged to create daylit spaces that enhance occupant comfort, health, and performance [3]. The varied light spectrums have psychological and physiological effects on people, and daylighting has been linked to greater mood, higher morale, less weariness, and less eyestrain. Besides, working in windowless environments, or environments that lack adequate illumination, may cause a severe disruption in the chronobiological system regulating hormone production [5]. Besides, improper consideration of daylight design factors can lead to uncomfortable interior environments with glare and excessive heat gain [6]. Designers need to ensure uniform light distribution, minimize glare, and consider students' visual performance and health [3]. The next section of the paper will review the important elements, challenges and strategies to implement daylight. Also, the next section is to present the results and discusses the outcome.

2. Literature review

2.1 Important Elements to Implement for Daylight in a Classroom

To achieve optimum daylighting in a classroom, several elements are important to consider that might affect the quantity and quality of daylight. Based on recent research and journals, the elements that we should focus on are the implementation of daylight in the classroom which are Window-Wall Ratio (WWR), Window or Building Orientation, Classroom Layout, Sun Shading Devices and Glazing Types and Materials. The details are as follows:

1.Window-Wall Ratio

Designing windows is crucial for improving building energy use, as it affects ventilation and lighting systems. Window Wall Ratio (WWR) optimizes daylight transmission, impacting indoor comfort and energy requirements. The ideal WWR for sub-tropical climates is 20%-30%, while for tropical climates, it's 30%-40% [5]. The Window-to-Wall Ratio (WWR) should be carefully chosen for a building's facade during the initial design phase [7].

2.Window or Building Orientation

Window orientation improves energy efficiency, making occupants more comfortable and productive. Hence, the most important criteria to consider is the direction of the buildings and windows facing daylight [8]. Furthermore, classes' orientations should be ideally parallel to the cardinal directions as the daylight’s glare penetrates the windows. The distribution of light differs widely across all the classes, with nearby window spots having very bright illumination compared with the far corners of the classroom [9].

3.Classroom Layout

The utilization of daylight in educational settings effectively offers a variety of advantages, including healthier students and improved productivity, as well as enhanced moods, learning abilities, and attention spans. It is crucial to comprehensively be aware of the various classroom functions that are affected by natural light because each one demands a distinct set of lighting settings It is very important to determine daylight quality that meets the classroom layout to ensure the occupant’s efficiency. There are six different aspects makeup students' emotional structures based on classroom layout: utility and layout, cosines and satisfaction, comfort and focus, modern design, daylight, outward-looking, and artificial lighting [2].

4.Sun Shading Device

Shading systems are designed to avoid unwanted daylighting and cut down on running expenses. They also improve the building's shading system and establish design capabilities to adapt to the user. Shading devices are preferable for daylight control in different seasons due to their ability to move with the sun's direction [10]. Effective external shading can minimize the energy required for air conditioning thus providing significant financial advantages. Thus, three factors that affect shading performance are the shading depth-to-window height ratio, opening width-to-height ratio, and facing orientation, the latter of which is related to building geography [11].

5.Glazing Types and Material

Choosing suitable materials for window glazing is important as it has a massive impact on the energy and daylighting performances of a building and can affect the occupant’s productivity. Daylight systems must consider design factors to ensure durability and efficiency. Hence, the physical characteristics of glazing materials should be considered such as thickness, colour, mass, density, texture, and temperature or thermal sensitivity. These factors affect the amount of daylight and solar heat transmitted [12, 13].

2.2 Challenges When Daylight Implemented in Classroom

To implement daylight strategies in classrooms, the common approach is firstly to identify the potential challenges faced by occupants. Numerous studies have been done on identifying the challenges for daylight implementation in classrooms across the countries. It is essential to review those studies to identify the potential challenges faced during daylight implementation in Malaysia. The identified challenges in literature are visual comfort, thermal comfort, Glare, Colour, and inadequate lighting distributions,

1.Visual Comfort
The right amount of light is essential for visual comfort, as it can be stressful and exhausting. However, sharp contrast or significant fluctuations in light levels can be stressful and exhausting. The problems with visual comfort in classrooms go beyond mere technical issues (Mehta, 2020). In addition, whenever a room "maximizes" daylight transmission to save energy on electrical lighting, nevertheless causes visual discomfort, internal shade mechanisms are frequently used, and formal changes are made to the facade, which drastically alters the architectural objective [14].

2.Thermal Comfort
Thermal responses have received the most research attention due to their potential to affect building energy consumption and mood. Physical changes such as heat gains and losses via glazing can also affect occupants' moods and productivity [18]. Furthermore, women are more sensitive to small temperature changes than men, and in a climate chamber investigation, they had lower thermo- neutral body temperatures than men (23.9 vs. 26.4 °C) [15].

3.Glare
Glare is a visual discomfort caused by an unsuitable distribution or range of luminance or extreme contrasts. Discomfort glare is caused by light scattering within the eye, which reduces the brightness contrast of the retinal image and hinders vision. Disability glare is caused by extremely bright glare sources, as the eye reacts physically to them [16].

4.Colour
Certain colours are more conducive to learning than others as warmer colours such as yellow, orange, and red are more pleasant and stimulating, while cooler colours like blue promote focus and pastel colours are beneficial for improving concentration and understanding. Selecting the ideal colour for classroom design are very crucial as it impacts the mood and productivity of occupants [17].

5.Inadequate Lighting Distribution
Poor lighting design, inadequate daylight utilisation, lack of maintenance and cleaning, poor colour temperature and lighting levels, and excessive glare and reflections can all affect the distribution of light in classrooms [18]. Furthermore, factors like overall glazing design, shading system, window’s direction and sun’s daily movement are very important to consider as they affect the luminance distribution in specific areas [19].

2.3 Strategies Based On Challenges to Enhance the Daylight Implementation in Classroom

Daylighting strategies have recently been a high priority for the government and universities as they provide many benefits towards productivity in the learning process, especially for students and lecturers. However, the challenges that decelerate daylight implementation, such as visual comfort, thermal comfort, glare, colour and inadequate lighting distributions further indicate that proper strategies should be considered to enhance daylight implementation in the classroom. There are various strategies based on challenges that can enhance the implementation of daylight in the classroom which are the implementation of smart windows and louvres tilt angle, utilizing natural or artificial air flow, egg-crate shading device, blind installation, electrochromic (EC) glazing, window-wall ratio and building orientation, soft colour for classroom interior, daylight spectral, and zenithal light pipe, solar trafficking system.

1. Visual Comfort: Implementation of Smart Windows and Louvres

Electrochromatic (Ec) smart windows enable dynamic control of solar radiation, resulting in optimal use of natural light during daylight hours, resulting in greater levels of visual comfort and savings on artificial lighting [20]. In addition, louvres are designed with openings to improve the view. The angle at which the louvres are tilted also affects the quality of the view. Therefore, having more open louvres enhances the view and improves its overall quality [21].

2.Thermal Comfort: Utilizing Natural or Artificial Air Flow, Egg-Crate Shading Device

Utilizing natural airflow can provide a cooling impact for building occupants while combating excessive heat. In addition, a well-designed skin façade or shading system can aid in minimizing heat transmission from the exterior to the interior of the space [22]. Using an egg-crate shading device is very suitable to implement in the classroom because it allows a longer duration of greater rolling shutter opening degrees, which affects indoor illumination and thus reduces the classroom temperatures that cause thermal discomfort [23]. egg-crate shading devices are ideal for warm climates by decreasing the amount of solar radiation and thus reducing interior temperature and discomfort hours. Furthermore, they work effectively from various sun angles [24].

3.Glare: Blind Installation, EC Glazing, Window-Wall Ratio and Building Orientation

Using suitable interior blinds in the form of moveable semi-transparent fabric panels or rolls provides the elimination of glare problems (Kent et al., 2017). EC glazing allows for uninterrupted view and selective light transmission, making it a superior shading system. It also protects against the sun causes glare discomfort and minimizes heating and cooling demands [25]. Hu et al. [26] found that a building's orientation and window-to-wall ratio (WWR) can affect how well it controls glare and provides daylighting. It is important to consider the unique circumstances of the building, its location, and its design when choosing an orientation and layout.

4.Colour: Soft Colour for Classroom Interior, Daylight Spectral

Light-colored walls, such as beige or light yellow, can improve daylighting performance by increasing the amount of natural light reflection in the space. Additionally, coloured windows can improve daylighting effectiveness by reducing solar radiation and enhancing colour rendering, as well as cutting down on energy used for cooling and lighting [23]. The spectral power distribution of the light source has the potential to influence how coloured items appear. White light and high CCTs promote task performance, while red or blue spectral tuning enhances alertness and cognitive function. Better daylight quality results from a colour shift in two directions (green and yellow) rather than one way [27].

5.Inadequate Lighting Distribution: Zenithal Light Pipe, Solar Traffic System

Zenithal light pipe systems can improve daylighting performance by distributing natural light evenly and reducing the need for electric lighting. They can also improve indoor air quality by lowering energy consumption for lighting and cooling [28]. The solar tracking system with a fixed light pipe is a daylight harvesting system that captures and distributes daylight in the building. It is inexpensive and simple to retrofit and uses a solar tracker and collimation to reduce variance in the light pipe's beam pattern during the day [7].

3. Methodology

The comprehensive literature review was summarized, and a questionnaire survey was developed using Google Forms. A close-ended survey method was employed by dividing it into several sections which are Section A: respondent's information, section B elements, section C: challenges and lastly section D: strategies for the implementation of daylight in the classroom. The respondents were required to rate each question according to the agreement level with a number between '1' to '5', where '1' indicated the lowest and '5' indicated the highest level of agreement. The determination of the 148 sample size is based on Krejcie and Morgan which consists of Architects, Engineers and Green Building Certified Facilitator or Assessor. The selection of respondents is based on their expertise in designing and being involved with green building projects.

The statistical package for the social sciences (SPSS) was used to conduct the Reliability Analysis gathered from Likert scale questions obtained from construction stakeholders. Reliability analysis will measure the internal consistency from the scales in each section through Cronbach's alpha coefficient test, α. The range of values of the Cronbach's alpha coefficient is 0 to +1. A Cronbach's alpha of 0.7 is considered adequate, whereas a score of 0.8 signifies extremely strong internal consistency. However, a low score from Cronbach's alpha coefficient test indicates that the data are inconsistent and have a low degree of interrelatedness. Afterwards, the SPSS software is also utilised in this study to calculate the mean value and the agreement level. The mean range was used to assess the level of agreement which is 1.00-1.50 (strongly disagree), 1.51-2.50 (Disagree), 2.51-3.50 (neither agree nor disagree), 3.51-4.50 (agree), 4.51-5.00 (strongly agree).

4. Results and Discussions

1.Important Elements to Implement for Daylight in a Classroom

In this section, respondents were asked to rate the important element to implement for daylight in a classroom. The rate of agreement of each type of important element to implement daylight in a classroom according to the Likert scale is shown in Table I. Desirable sun shading devices were ranked as the highest important elements to be implemented with a mean value of 4.28. According to Dagher et al. [29] the use of sun shading is a strong method to minimise solar transmittance and heat gain through a window, especially in hot climates. Sun shading can be internal or external, however, external is said 30% effective in reducing solar heat gain. Bian et al. [4] highlighted that the presence of daylight may cause reflection on the boards in the classroom which disrupts students and affects the visual and efficiency in learning. Therefore, shading such as switchable blinds can be designed to achieve a balance between daylight availability, visual comfort, and the view from the window. Classroom layout was ranked the second most important element to implement for daylight in a classroom with a mean equal to 4.12. According to research by Callejas et al. [30] stated that achieving optimal daylighting in classrooms is important in a well-designed layout that facilitates the entry of natural light while ensuring a uniformly illuminated space without causing glare on work surfaces. Additionally, the distribution of lighting is influenced by the materials, colours, and textures of the interior surfaces, as well as the geometric proportions of the classroom. Taking these factors into account is crucial for optimizing both the visual and thermal comfort of students [2].

Appropriate Window Wall Ratio (WWR) was ranked the third important element to implement for daylight in a classroom with a mean equal to 4.08. Ayoosu et al. [31] stated that it should be emphasized that the optimal window-to-wall ratio (WWR) can vary based on the unique context and climate of a classroom According to Xue et al. [32] the window-to-wall ratio is the ratio between transparent area and the total façade surface which is an important parameter and gives a huge impact for the daylighting and energy. The window-to-wall ratio is an important element for the building envelope to achieve efficient indoor luminous and thermal comfort.

However, window shape and suitable glazing material were ranked the second lowest important element to implement for daylight in a classroom with a mean equal to 3.88. [32] stated that designing a window is the key element for daylighting that holds significant importance in ensuring visual comfort and reducing energy consumption in buildings. In addition, selected glazing material effectively supports the transmission of natural light, enhances thermal comfort, provides visual well-being, and contributes to energy-efficient building design [32].

Window geometry was ranked the least important element to implement for daylight in the classroom with a mean equal to 3.84. Even though most participants ranked window geometry as the lowest important element however it is important to carefully consider window geometry as it is essential in daylighting design to ensure the efficient distribution of natural light, enhance visual comfort and thermal, and promote the productivity of the occupant. According to Liu et al [18], appropriate window geometry can play a positive role in effectively utilising natural light and gaining a comfortable light environment. Window geometry can improve learning efficiency, reduce energy consumption and at the same time benefit user's physical and mental health.

Table 1
Mean results for elements when implementing daylight in the classroom

Elements	Mean	Level of Agreement	Ranking
Appropriate Window to Wall Ratio (WWR)	4.08	Agree	3
Acceptable Window Orientation	4.04	Agree	6
Building Orientation	4.00	Agree	9
Classroom Layout	4.12		2
Desirable sun shading devices	4.28	Agree	1
Suitable Glazing Types	4.00	Agree	8
Suitable Glazing Materials	3.88	Agree	11
Quantity of window	4.04	Agree	5
Room height	4.04	Agree	4
Window shape	3.88	Agree	10
Window geometry	3.84	Agree	12
Sun's daily and seasonal movement	4.00	Agree	7

2. Potential Challenges when Daylight is Implemented in the Classroom

In this section, respondents were asked to rate each factor according to its significance as a challenge faced when daylight is implemented in the classroom. The perspectives on each challenge are shown in Table II. The results are then ranked according to the mean value analyzed by SPSS, as shown in Table 4.3. Among five (5) challenges listed in the online questionnaire survey, providing adequate lighting distribution in certain areas was ranked as the top challenge faced by the stakeholders when daylight is implemented in the classroom with the highest mean value which is 4.13. According to research by Liu et al. [18] there is a lack of cleaning and maintenance of lighting fixtures, low illumination levels, and colour temperature, and too much glare and reflection. Changes in the environment, such as the weather and neighbouring structures, can also affect how light is distributed in classrooms.

Meanwhile, thermal comfort was ranked second in potential challenges when daylight is implemented in the classroom with a mean equal to 4.04. Thermal comfort refers to the pleasant or favourable state of mind individuals experience in terms of their perceived warmth or coolness. It is closely tied to the surroundings in which a person finds. Despite its name, it has a broader impact beyond just comfort, affecting productivity, overall health, and well-being. Consequently, being satisfied with the thermal environment is very significant, but, achieving thermal comfort based on the preferences of an occupant is very challenging as stated by Chinazzo et al. [34] which the presence of daylight can impact how people perceive temperature, creating a cross-modal effect.

Furthermore, visual comfort was ranked third in potential challenges when daylight is implemented in the classroom with a mean equal to 3.96 and standard deviation equal to .889. According to research by Liu et al. [35] an unfavourable daylight environment in classrooms can exert a substantial impact on the vision of college students, leading to discomfort and potential visual impairments.

In addition, colour selection when designing learning environments for classrooms was ranked fourth position in potential challenges when daylight is implemented in the classroom with a mean equal to 3.96 and a standard deviation equal to 1.020. The finding of the research by Kraus & Nováková [36] is the colour of the interior spaces significantly impacts visual comfort. In addition, the combination of applied colours, surface materials, and indoor lighting can influence students' receptivity, behaviour, and mood of occupants.

Lastly, Glare (i.e: direct view of the bright sky) was the least potential challenge when daylight is implemented in the classroom with a mean equal to 3.96 and a standard deviation equal to 1.122. Glares caused by direct sunlight or excessively bright sky views can have negative effects in indoor settings such as offices and classrooms. It can hinder eyesight, create discomfort, and make tasks difficult to complete or screens hard to see. High luminance or sharp contrasts in the field of view can also contribute to glare [37].

Table 2
Mean results for challenges when implementing daylight in the classroom

Elements	Mean	Level of Agreement	Ranking
Visual Comfort (i.e:light level, contrast)	3.96	Agree	3
Thermal Comfort	4.04	Agree	2
Glare (i.e: direct view of the bright sky)	3.96	Agree	5
Colour selection when designing learning environments for classrooms	3.96	Agree	4
To provide adequate lighting distributions	4.13	Agree	1

3. To Propose Strategies based on Challenges to Enhance Daylight implementation in a Classroom

The respondents were also asked to propose strategies based on challenges to enhance daylight implementation in the classroom listed in Table III. The first challenge is to provide adequate lighting distribution, the strategy is installing a Zenithal Light Pipe or Solar Trafficking System. According to research by Onubogu et al. [38] zenithal light pipes can enhance the distribution of natural light in spaces like classrooms, ensuring more even and uniform illumination. Furthermore, Chen et al. [39] stated that solar trafficking systems in daylighting employ mechanical mechanisms to capture sunlight and enhance the efficiency of light collection by dynamically adjusting the position of solar panels to track the movement of the sun throughout the day. This continuous movement optimizes the angle at which the panels receive solar radiation, maximizing their ability to capture sunlight.

The second highest strategy based on challenges to enhance daylight implementation in the classroom is thermal comfort. Thermal comfort challenge can be improved by utilizing natural or artificial air flow, egg-crate shading device. This is Agreed by the respondents with a mean value equal to 3.96. Lim et al. [40] stated that egg-crate shading devices are considered highly suitable for effectively blocking sunlight and reducing cooling energy consumption, which ultimately leads to improved thermal comfort in a space. Moreover, research by Costa et al. [28] shows air circulation quality in spaces is influenced by window opening size, placement, and control. Proper ventilation requires well-designed openings and regulated fittings, while upper-level ventilation removes warm air and promotes a healthier indoor environment.

Meanwhile, the respondents also agree that the implementation of smart windows and louvres is another strategy to tackle the challenge of visual discomfort to enhance daylight implementation in classrooms. The mean value achieved is 3.80 which indicates as Agree. Cannavale et al. [20] stated that electrochromic (EC) smart windows provide an innovative solution for dynamically regulating the transmission of solar radiation through windows. Meanwhile, exterior louvres must possess durability to withstand wind loads and weather conditions while avoiding unintended movement and noise.

Then, for the challenges in terms of colour, The respondents Agree with a mean value of 4.00 that the strategy is to use soft colour for classroom interior and utilisation of daylight spectra. Research by Geng et al. [41] shows that brighter light increases well-being and energy levels, while lower colours create security, positivity, and tranquillity. Warm white light creates a positive atmosphere while selecting suitable colours enhances visibility, visual comfort, and aesthetic appeal.

Lastly, the majority of respondents agree that blind installation, Electrochromic (EC) glazing, Window-Wall Ratio (WWR), and Building orientation become suitable strategies for the glare challenges. The mean value achieved is 3.84. The interior blinds can diminish the intensity of sunlight, resulting in a more favourable environment for clear vision and uninterrupted work. By mitigating glare, they contribute to enhanced visual comfort and reduce eye fatigue. Furthermore, EC glazing has the potential to effectively minimize sun glare, enhancing visibility and enabling uninterrupted work without distractions or discomfort [42]. Lastly, Hu et al. [26] stated that a building's orientation and the proportion of windows to walls ratio (WWR) can have a considerable impact on its ability to manage glare and offer effective daylighting. The research further revealed that different WWRs and orientations can lead to varying levels of thermal comfort and glare.

Table 3
Strategies based on challenges to enhance daylight implementation in a classroom

Elements	Mean	Level of Agreement	Ranking
Lighting Distribution: Zenithal Light Pipe, Solar Trafficking System	3.88	Agree	3
Thermal Comfort: Utilizing Natural or Artificial Air Flow, Egg-Crate Shading Device.	3.96	Agree	2
Visual Comfort: Implementation of Smart Windows and Louvres	3.80	Agree	5
Colour: Soft Colour for Classroom Interior, Daylight Spectral	4.00	Agree	1
Glare: Blind Installation, Electrochromic (EC) glazing, Window-Wall Ratio and Building Orientation.	3.84	Agree	4

4. Conclusion

This study critically evaluated twelve (12) important elements to implement for daylight in the classroom. This study has also been achieved which is to investigate the potential challenges when daylight is implemented in the classroom. There are five potential challenges indicated when daylight is implemented in the classroom which are visual comfort, thermal comfort, glare, colour selection when designing the learning environment, and providing adequate lighting distributions.

Overall, the implementation of daylight strategies in a classroom is crucial for creating an optimal learning environment that supports student engagement, well-being, energy efficiency, and compliance with building standards. It is a holistic approach that benefits students, construction stakeholders, and the educational institution. The limitations of the study include the exclusive focus on stakeholders directly involved in the green building, potentially overlooking valuable insights from end-user such as students and lecturers. These limitations should be considered when interpreting the results and applying the study's recommendations to diverse educational environments.

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