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Optimizing Lighting Strategy in Classroom using DIALux Software: Case Study of GKU-B Indonesia

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Abstract. Lighting system has been an active element in educational environment. Lighting plays a great role in designing classrooms in an institution. Inadequate lighting environment may result in poor task performance of learning activity. This paper will demonstrate how lighting strategy will affect the illuminate level in a classroom. The location of case study is General Lecture Building – West, Bandung Institute of Technology, Indonesia. Lighting strategy used will be implemented based on the needs of problems assessed during the existing simulation and field survey. In order to verify an efficient lighting system in a classroom, consisting of artificial and natural lighting, a help of specialized software called DIALux Evo is used.

INTRODUCTION

Many elements affect environments, in which indirectly also affect people [1]. Lighting is an active element of an educational environment. Lighting has always been an important factor in designing school or institution [2]. Aspect of classroom lighting can promote discomfort and significantly impact task performance of learning activity, hence directly affecting student and teachers [3,4]. However, some schools and institutions still have an inadequate efficient lighting system which impacts the teaching-learning process [4,5].

Designing an efficient lighting system has currently been a major topic in energy conscious design [6,7]. Optimizing spatial luminosity can be done using several aspects of lighting strategies, such as creating a light shelf, use of motion sensor lamp, etc. [8,9] It is a crucial for a designer to understand the relationship between light and space to implement an effective system of lighting. In order to optimize and verify the efficiency of this spatial luminosity, a specialized software is used such as DIALux Evo [8].

This paper will discuss how lighting strategy will affect the illuminate level in a classroom, to implement an efficient lighting system in a classroom, consisting of artificial and natural lighting [10]. Aside from the proposed design modification consisting of lighting strategy, specialized illumination software DIALux Evo will be used to verify illumination level of the classroom. Case study used is General Lecture Building - West (GKU - B). Simulated exterior illuminance levels based on measured solar radiation and cloud cover data in the GKU-B are used to estimate interior illumination on normal working planes.

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METHODOLOGY

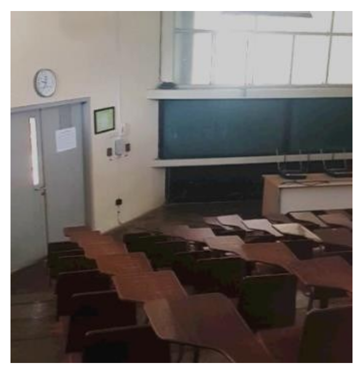
Case Study

GKU - Barat is located at position 6°53'25" South Latitude, 107°36'32" East Longitude or south of Labtek II which is on the west side of the campus. At first, the three-storey building which had the shape of an octagon was called the General Lecture Building (GKU). However, because there was another GKU on the east side of the campus, this building was then called the "West General Lecture Building (GKU)" or "Old GKU". This Public Lecture Building has been operating since the beginning of 1986. The ground floor is used for 4 classrooms, several seminar rooms, a canteen and toilets. The second and third floors are each used for 8 classrooms and a supporting room in the form of a toilet. The total number of GKU - Barat lecture halls is 20 rooms in the form of an amphitheater with a maximum capacity of 100 people.

GKU-B was first used for student lectures class of 1985 and is still operating today. The age of the building, which is almost 40 years old, has become a pride and historic icon for the ITB campus. However, behind that, the building is starting to show some operational problems in an effort to meet the demands of learning activities, especially in this post-pandemic period. Several issues related to minimal lighting, visual and thermal discomfort were noticed especially during day. In an effort to respond to these problems, it is necessary to have solutions that are integrated with an interdisciplinary architectural approach, of which is through the integration of concepts, methods and analysis that can intervene in the previous GKU-B design.

Based on the GKU-B location survey, the natural lighting conditions in the classrooms were inadequate for teaching and learning activities. There are only 2 windows, on the east and west wing, as shown on Fig. 1 (a). As Fig. 1 (b) shows, classroom on the third floor is facing many problems such as; poor daylight environment and visual discomfort, unbalanced levels of daylight near to the window and the inner parts and overheating. The existing condition of the GKU-B classroom has a high level of lighting around the windows, but the middle back of the room does not meet SNI with the lowest value of 239 lux. Then, natural and artificial lighting in the existing conditions of the GKU-B class room at the back of the middle of the room do not meet SNI with the lowest value of 292 lux. Uneven distribution of lighting can be seen in each classroom, causing the room to be dependent to artificial lighting.

(a)



(b)

FIGURE 1. (a) Atrium GKU-B, exterior window of GKU-B Classroom; (b) Interior Classroom of West GKU.

Research Method

The research method is divided into 3 (three) stages, namely data collection methods, design methods, and data simulation methods. The method used in the data collection process is through surveys or existing field studies. The results of the field study will then be simulated to evaluate the existing lighting system. The design method is carried out by responding to the results of field studies with designs that are suitable for optimizing room lighting. Next, a simulation will be carried out, to verify the results of the lighting system design. Calculation of the results of the illumination data from the existing simulation will be presented through pictures and graphics for later comparison with the building illumination standards in Indonesia (SNI). With the help of DIALux Evo software, a room will be simulated and then the amount of light and the distribution pattern of light in the room will be calculated. In the verification process, the types of materials, orientation, used in modeling must be made as similar as possible to the conditions in the field. After the verification process, the model will be optimized using DIALux Evo software, this aims to verify the results of design modifications as a solution to the problem.

The following is each step of the whole process: survey and analyze of the existing natural lighting conditions of existing building. Then, we should determine the amount of sufficient lighting requirements according to Indonesian National Standard (SNI). Then we simulate of existing lighting condition in the GKU-West room using DIALux evo. After that, we response to the simulation results with several design solution. Last, we simulate of final proposed design solutions using DIALux Evo.

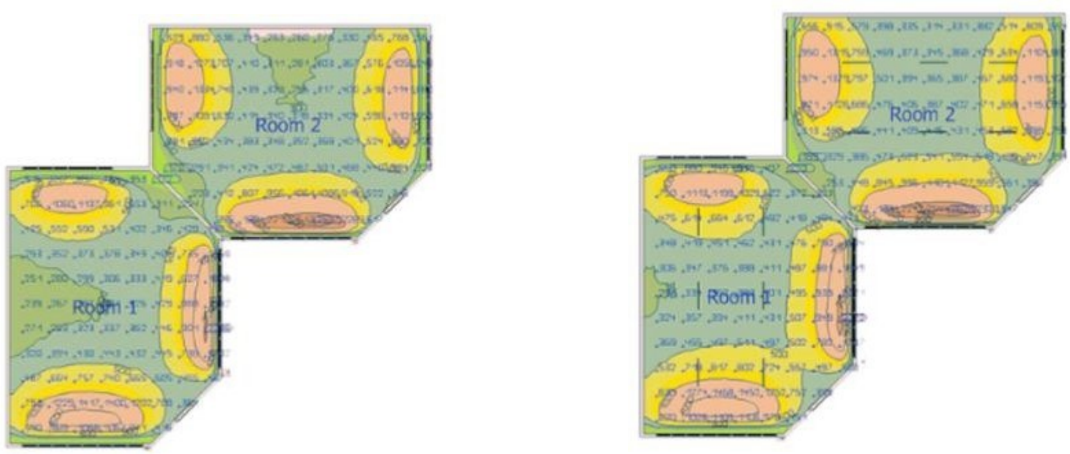
RESULTS AND DISCUSSION

Existing Condition

After conducting a field survey, GKU-B has **insufficient** natural lighting for teaching and learning activities. One of the reasons for this is that the cantilever or overhang distance used as a circulation path has quite long dimensions, namely ±2m from the opening in the outermost wall of the class. In addition, the incoming light is not well distributed into the classroom so that it is only concentrated in the area closest to the opening. Using DIALux Evo simulation, as shown in Table 1. the existing condition of the GKU-B classroom has a high level of illuminance around the windows, but the middle back of the room has lowest value of 239 lux. Then, natural and artificial lighting in the existing conditions of the GKU-B classroom at the back of the middle of the room has the lowest value of 292 lux. Meanwhile, the standard value for a classroom should be at least 350 lux. This proves that the lighting level at all spots are **inadequate** and **uneven.**

TABLE 1. Result of Dialux Evo simulation of existing classroom condition.

Existing Classroom Condition	Illuminance Level (lux)	Standard Illuminance Level (lux)
Without Artificial Lighting	239	350
With Artificial Lighting	292	350



(a) (b)

FIGURE 2. (a) Result of DIALux Evo simulation of existing condition without artificial lighting; (b) Result of DIALux Evo simulation of with artificial lighting.

This uneven distribution of lighting can be seen in each classroom, causing visual discomfort. Therefore, the design of GKU - Barat requires innovation in natural and artificial lighting systems that are designed and modified, according to the illuminance level standards of SNI 6197:2011 which is 350 lux, to support learning activities in the classroom using the DIALux Evo software.

Lighting Design Modification

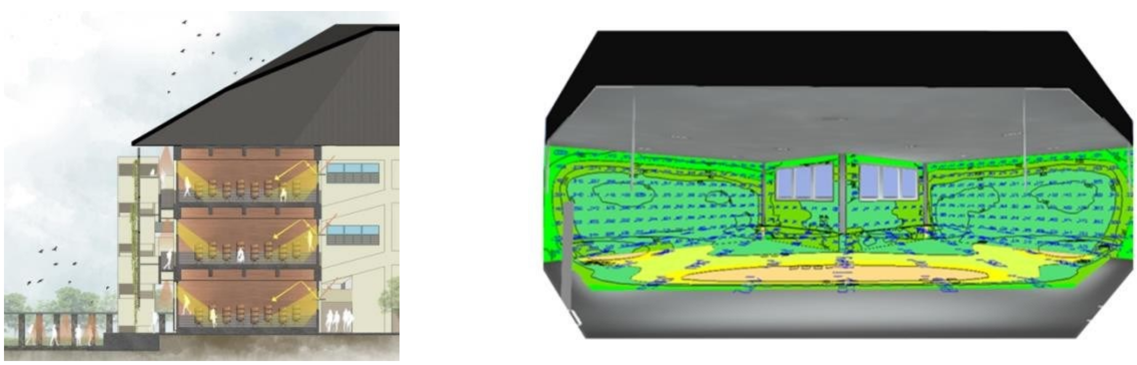
After conducting simulation, DIALux Evo initiates several modifications to optimize the artificial lighting for the classroom. The simulation shows that 9-16 Watt LED lamps are needed for large classrooms and 5-16 Watt LED lamps for small classrooms. One of the strategies is to use a motion sensor lamp, on the circulation path, sensors are scattered at several points to detect movement. A moving object will be detected by the sensor and then the light will turn on for five minutes. If within that time no object is detected, the light will turn off. This also supports energy efficiency efforts in the design of the GKU-B building.

In addition, light shelf and high-performance glass are also proposed in the design modification. Light shelves are used to distribute natural lighting into the classroom so that the lighting becomes more even. The light shelf material uses reflective material (Aluminum Composite Material) so that it is expected to distribute natural light properly. Then, the glass in each opening uses high performance glass to increase the illumination of incoming light without increasing the air temperature in the room. [6,9].

Furthermore, there is the implementation of perforated metal sheet. The second skin in the form of a perforated metal sheet is used at several points of the GKU - B facade to help visualize the circulation area so that user mobilization takes place comfortably. Apart from that, the second skin is also overgrown with vegetation to with the passive cooling.

TABLE 2. Result of DIALux Evo simulation of existing classroom condition.

Lighting Strategy	Location of Installation
Light Shelf Installation	2 Windows on East and West Side
Motion Sensor Lamp	Circulation Path in Classroom
High Performance Glass	2 Windows on East and West Side
Perforated Metal Sheet	Outside the Classroom Window (Façade)



(a) (b)

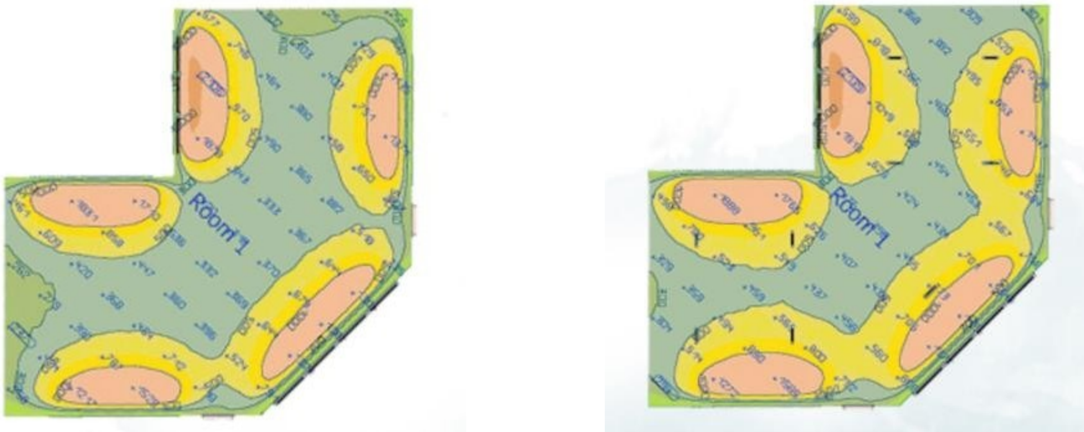
FIGURE 3. (a) Sectional Area of Lighting System Design (b) Modelling in DIALux Evo Software.

Modified Condition

In order to optimize natural lighting, lighting modeling was carried out using DIALux evo which were simulated on the third floor of GKU-Barat. In this task, DIALux evo is used for simulation after integrating natural and artificial lighting system innovations using the help of Grasshopper for natural lighting system.

TABLE 3. Result of Dialux Evo simulation of existing classroom condition.

Existing Classroom Condition	Illuminance Level (lux)	Standard Illuminance Level (lux)
Without Artificial Lighting	290	350
With Artificial Lighting	350	350



(a) (b)

FIGURE 4. (a) Result of DIALux Evo simulation of modified classroom condition without artificial lighting (b) Result of DIALux Evo simulation of modified classroom condition with artificial lighting.

As Table.1 shows, the illuminance level for modified classroom condition without artificial lighting still **has not met** SNI 6197:2011 requirement. However, the simulation shows an increase in illuminance level from 239 lux to 290 lux from the existing condition. For the modified classroom with artificial lighting, DIALux Evo shows that the illuminance level has increased to 350 lux, which meets SNI 6197:2011 requirement.

CONCLUSION

This paper has demonstrated how illuminance level of a classroom can be optimized using design strategy in a classroom. Through field survey, existing condition of GKU-B shows an **inadequate** illuminance level for teaching and learning activities. The lighting design strategies such as, light shelf, location of LED lamps, motion sensor lamp, and perforated metal sheet for façade are applied to the classroom. In order to solve the problem, these lighting strategies are adapted to meet the needs of the problem assessed on existing simulation, with a help of DIALux Evo software recommendation. After going through several modifications, it shows that these lighting strategies increase the illuminance level up to 19.8 - 21.9% with and without artificial lighting. Hence, these illuminance level has met SNI 6197:2011 requirement.

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