Quality Evaluation of Natural Lighting and Visual Comfort in the Classroom

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ABSTRACT

Natural lighting is an important consideration in effective classroom design to support learning activities. The most important factors in maximizing natural lighting are facade design, window openings, and building orientation. The purpose of this study is to assess the quality of natural lighting in the SMA Negeri (SMAN)/ Public High school 6 DKI Jakarta school building. This study examines how the design of window openings and facades affects lighting quality and how current classroom design conditions affect students' comfort while carrying out learning activities. The analysis in this study uses the DIALux software to simulate and measure the level of natural lighting in classroom and laboratory. From the results of the study, it was found that the level of natural lighting has met the standard but still needs to be optimized by classroom design factors such as window height positions, student heights position, and some interior attributes.

Keywords: Classroom, Natural lighting, Visual comfort, Window, Design.

1. INTRODUCTION

Lighting is a very important aspect to support learning activities in school buildings. Good lighting settings in the classroom need to be conditioned from natural and artificial lighting. The purpose of natural lighting is to get lighting in the building space during the day.

The benefits of natural lighting in the classroom have been proven by several studies. Heschong Mahone Group [1] confirmed that the researched more than 20,000 elementary students and 100 schools in the USA approved the effect of sufficient day lighting in classrooms increased 26% faster in reading and 20 % quicker in mathematics [2]. Health benefits and natural lighting in the classroom explained that natural light is shown to benefit the health, concentration and even test scores of students, and also improves immune quality and blood pressure [3]. Meanwhile, in relation to energy saving, optimizing natural lighting in buildings is known could reduce energy consumption to 40-45% [4].

Indonesia, as a tropical country with a very large duration of sunlight, is a potential that should be utilized to obtain optimal natural light. Buildings located in humid tropical climates get abundant sunlight intensity. With the duration of solar radiation is relatively stable throughout the year, namely between 06.00 -18.00 or between 10-12 hours [5].

Window openings are part of the building where natural light enters. Public school buildings in Indonesia generally have almost a similar design. This includes SMAN 6 Jakarta, where the design of the classrooms and window openings has become a design that is in accordance with the recommendations. In determining the window design, it is necessary to pay attention to many factors such as orientation, window wall ratio, and type of glass. These three factors are very important to create optimal lighting quality but also do not cause a reduction in the thermal comfort in the room.

It should be noted that natural lighting for the convenience of learning and teaching activities must also pay attention to its visual comfort, especially in avoiding glare. The window display is one of the factors that affect the uncomfortable glare sensing from the window [6], and certain positions in the classroom have the potential to get direct or indirect glare. By setting the table interior, chairs facing the white board, it is also necessary to evaluate which positions are less than optimal in terms of visual comfort due to glare.

From the description above, the purpose of this study is to obtain information about natural lighting in classrooms, especially at the location of a high school in the city of Jakarta, namely SMAN 6 Jakarta. Thus, it is hoped that information will be obtained regarding compliance with the standards recommended in the National Standard (SNI) regarding building lighting.

2. METHODS

In this study, natural lighting testing was carried out in two room which were classroom and laboratory in the SMAN 6 Jakarta building. The simulation were conducted to determine the intensity of natural light in classrooms. The simulation was carried out using the DIALux lighting simulation software and the use of a lux meter. From the results of the DIALux simulation value, it is then adjusted to the recommended standard of lighting intensity, namely by looking at the SNI 6197-2011 [7]. The value of the recommended average level of illumination in SNI 6197-2011 can be seen in Table 1.

Table 1. Standard recommendation of average lighting level

| Room Function	Lighting Level (Lux)
Classroom	350
Library	300
Laboratory	500
Drawing Room	750

(Source: SNI-6197-2011)

The sample classroom was selected by taking into account the orientation position of the room. In carrying out the simulation several steps are considered, including:

- Documentation the condition of the room samples: by collecting measurable image documentation to determine the dimensions of the classroom and window openings. List the interior and classroom furniture settings, the color of the walls, floors, ceilings.

- Setting general weather conditions and time setting: In simulating the natural lighting of the classroom, it used the setting for sunny weather conditions and for the simulation hours set at 10.00 WIB, which is assumed to be the time the teaching and learning activities take place.

3. RESULTS AND DISCCUSION

SMAN 6 Jakarta is located in the South Jakarta Region of Indonesia with coordinates 6°14'33"S 106°47'50"E. The facilities at SMAN 6 Jakarta include classrooms, laboratories, library, a canteen, etc. An illustration of the condition of the SMAN 6 Jakarta building with respect to the sun's position can be seen in Figure 1.
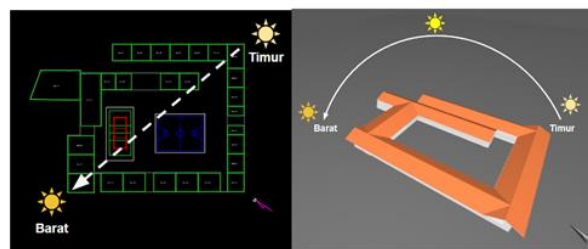
Figure 1 Illustration of the position of the SMAN 6 Jakarta building against the sun's position.

When viewed from the orientation of the sun, the school building has great potential in utilizing natural lighting in the room if the planning for transparent openings takes this into account, because the building envelope diagonally receives sunlight from East to West (Figure 1). Although there are indeed some rooms on the Northeast side that do not get natural lighting at certain times, this is due to the addition of a building for classrooms adjacent to the classroom building next to it (Figure 2).
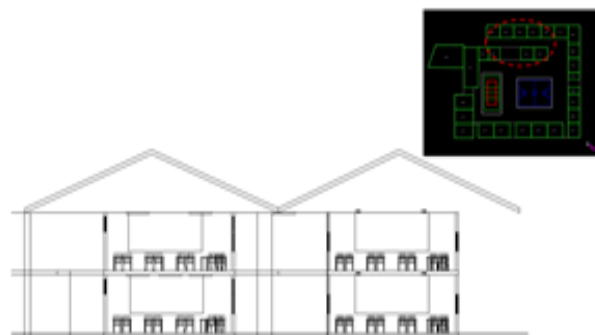
**Figure 2** Position of lighting measurement at SMAN 6 Jakarta.

The sample classrooms selected were the classrooms on the 2nd floor in the northeast position and the 2nd floor laboratory room. In the southwest position. For the wall color of the two samples the room were using a light green color with a bright reflectivity level of 70-90%. Floor material were using white ceramic, with ceramic reflectance of 65-75%, while the glass material for window in the facade of the classroom using clear glass.

3.1. *Evaluation of Natural Lighting in the Classroom*

Figure 3 The condition of the object measuring the level of lighting in the northeast orientation of SMAN 6 Jakarta.

In the classroom of the new building on the side on the 2nd floor, the DIALux software simulation was carried out at 10.00 WIB. At that hour, optimal natural lighting is obtained which enters more than 350 lux, covering an area of 50% of the classroom area. This can reduce by 50% of the use of electrical energy in the room lights in the morning until the afternoon (Figure 4)
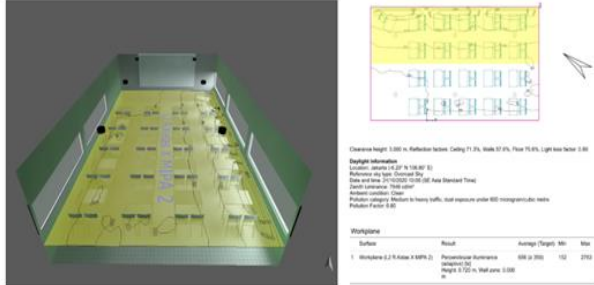
Figure 4 Simulation results of classroom lighting levels at SMAN 6 Jakarta.

Based on the direct survey results, the classroom window glass material uses clear glass, but in the classroom the classroom window glass openings are closed using curtains with the aim of blocking the glare. The use of curtains will certainly prevent the entry of natural light into the classroom (figure 5).

Figure 5 The condition of the occurrence of glare in the classroom of SMAN 6 Jakarta.

From the results of observations in the field, the cause of glare is due to the sill height of the window that is parallel to the height of students when sitting. In actual conditions, by closing the windows with curtains, impacted to the use of artificial lighting. However, the lighting level of the existing lamps still does not meet the standards, because the lighting system planning has not been designed properly (figure 6).

**Figure 6.** The condition of the lamps used in the classrooms of SMAN 6 Jakarta.

3.2. Evaluation of Natural Lighting in the Laboratory

The condition of the object for measuring the level of lighting in the laboratory room at SMAN 6 Jakarta (figure 7.)

Figure 7 The condition of the object for measuring the level of lighting in the laboratory room at SMAN 6 Jakarta.

From the simulation results using DIALux Software on the level of natural lighting in the laboratory room on the 2nd floor of the Southwest side of the school building, it was found that optimal natural lighting entered > 500 lux covering an area of 75% of the classroom area. This can reduce at least 50% of the use of electrical energy in the room during the use of the classroom for teaching and learning (Figure 8).
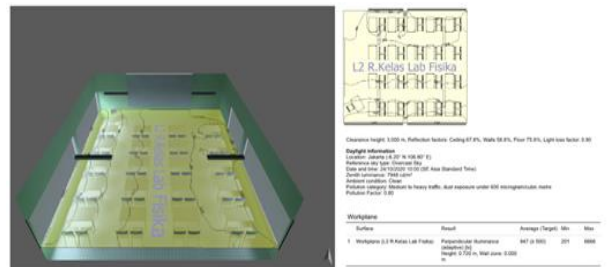
Figure 8 Results of measuring the level of lighting in the laboratory at SMAN 6 Jakarta.

4. CONCLUSIONS

It was found that the level of natural lighting in Classroom and Laboratory that used as sample in SMAN 6 Jakarta have met the standard (> 350 lux for classroom) and (500 lux for laboratory). However, this condition is still needs to be optimized. With the condition of classrooms in SMAN 6 which planning is not optimal, in terms of orientation, the sides are still blocked, glare and incoming heat radiation. Although natural lighting is good enough, it cannot be denied that for the visual comfort of the classroom, artificial lighting is needed.

Design factors such as window height position, student height position, and several interior attributes are things that reduce the quality of visual comfort in the classroom. The conditions found includes glare, wall color selection, and curtains that cover the entry of natural lighting.

For further research, it is recommended to increase the sample classroom and measurement time to obtain more data and more accurate results.

ACKNOWLEDGMENTS

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