



## Optimization of Lighting Intensity in Batam Public Library Reading Room

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### ABSTRACT

Lighting is one of the most critical components that support human life and other living creature. Poor illumination can impede users' ability to use a building or space effectively. Library is one of the places that require good light spread so that users feel comfortable when doing activities in it. The Batam City public library is a library located on the fourth floor of the Batam City joint office. This library only has four small apertures in the form of windows for a 13.2 meter x 9 meter area, therefore sunlight cannot distribute evenly. Therefore, one solution to ensure that the library room has a suitable distribution of light is to employ artificial lighting. According to a questionnaire distributed to visitors and staff of Batam City public libraries, 82.4% of respondents believed that lighting in Batam City public libraries was still inadequate. This study used data from direct field observations, interviews with staff and library visitors, questionnaire distribution, and literature review. This research uses quantitative methods by calculating light intensity through the simulation of dialux software. Simulations were carried out in the catalogue room and the library reading room. Changing the colour of the wall surface, the furniture arrangement and the lights' placement are some experiments done to provide a good distribution of light. This study aims to evaluate and obtain lighting simulation results for the public library in Batam City that adheres to the SNI standard (300 LUX).

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## 1. INTRODUCTION

Lighting is one of the aspects that contribute to creating a safe and comfortable atmosphere, which influences the activities and productivity of its users (Indah et al., 2021). Light is crucial in conveying visual information to the eye; without light, the eye cannot function properly (Masrokan et al., 2020). Light is an important factor to consider while planning a building. All building users' activities have an impact on the light's quality. Poor lighting hurts job efficiency since it causes eye tiredness, mental fatigue, headaches, and eye injury (Lasa in Anisatun & Jumino, 2019). Lighting quality, lighting quantity, and lighting regulations (Permana et al., 2022) are a few of the fundamental requirements (Permana et al., 2021) for good lighting. The level of light intensity must be controlled so that room users do not experience glare or a lack of light and so that room users are comfortable (Fleta, 2021).

One of the public buildings that need sufficient illumination is the library. This is because illumination is crucial for various library activities, including reading and working (Larasati & Juvitasari, 2022). Based on observations and measurements taken using a lux meter at the Batam City library on April 28, 2022 from 09.00 to 12.00, it was discovered that the illumination did not satisfy the SNI requirement (300 LUX) and only ranged from 100 lux to 200 lux.

According to the findings of distributing questionnaires (Kencanasari et al., 2020) to 35 visitors and Batam City public library officers with an average age of 20 to 29 years, 67.6% of respondents felt visually uncomfortable with lighting while in the library, 64.7% felt uncomfortable (glare) when completing activities at the window front desk, and 82.4% believe that lighting in the Batam City public library is still not good.

A light's low quality will affect how comfortable it is to use visually, which will impact how well work is done in the room. Therefore, study on the visual comfort of the lighting in Batam City public libraries is required in order to ensure that the libraries have the proper lighting that complies with SNI criteria.

## 2. LITERATURE REVIEW

### **Illumination**

Light is an important factor to consider while planning a building. Paying attention to the quality of the lighting is one of the keys to creating a secure and comfortable room (Indah et al., 2021). Poor illumination can have several detrimental effects, including diminished productivity owing to eye fatigue, headaches, and eye injury (Lasa in Anisatun & Jumino, 2019).

Artificial lighting and natural lighting are the two types of lighting systems. Natural lighting is light produced by the sun during the day, whereas artificial lighting is produced by sources other than the sun (Amin, 2011). Artificial lighting is required, especially at night and in spaces that the sun cannot illuminate (Sutanto, 2019). Artificial lighting entails more than just putting bulbs and consuming a lot of energy; the quality and quantity of lighting must also be considered. This is because proper lighting is a crucial component that can influence the mood of a space (Rohadi et al., 2017).

## Lamps

In artificial illumination, bulbs come in a variety of shapes and sizes (Febriyursandi et al., 2019), including:

1. Incandescent lamps are lamps that generate light by heating the lamp filament
2. Fluorescent bulbs are commonly used lamps. This lamp produces UV radiation when the mercury vapor pressure is low
3. High intensity discharge (HID), is a type of light that is created when an electric discharge passed through the vapor of a metal material. This light takes between 3 until 8 minutes to provide appropriate lighting
4. The newest form of lamp is the light emitting diode (LED). The lifespan of this bulb is extensive (up to 40.000 hours)

## Library

A library is an institution that governs written works, printed works, and recorded works to satisfy the demands of the educational world. A library is also a collection of books and periodicals (UU No 43 Tahun 2017 Tentang Perpustakaan) Library is also a public resource that functions as a communication hub for all communities (Mampuni et al., 2017)

Libraries come in a variety of forms (Mampuni et al., 2017)

1. An international library is one that has been built in collaboration with two or more countries as part of an organization
2. A national library is a library that has been built to store a wide variety of printed and recorded library items issued in a country
3. A public library is a library with a collection encompassing a wide range of scientific areas, and it is managed using a general budget and serves to serve the general public
4. A private library is governed by a private institution or individual, and it is not open to the public and only serves a certain group
5. An exclusive library is housed within a state owned or privately held organization or agency. This library has a function as a support to improve knowledge for certain circles

## Batam City public library

Batam is one of the cities in the Riau Islands with a public library in the Batam Center area. The Batam City public library building is a mixed-use structure that serves several activities, such as the Batam City environmental impact control service, the Batam City energy and mineral resources trade industry office, the Batam City national and political

unity agency, the Batam City city planning office, and others. The public library for Batam City is located on the fourth floor of the joint office building in Batam Center.



Figure 1: Batam city public library  
Source: Author, 2022

The public library in Batam City is separated into a number of rooms. There are circulation service rooms, reading rooms, digital rooms, reference rooms, and staff work areas. The catalog and reading room, which is the main room of the Batam City public library, will be examined in this research. The reading room and catalog room of the public library in Batam City are 13.2 meters by 9 meters.

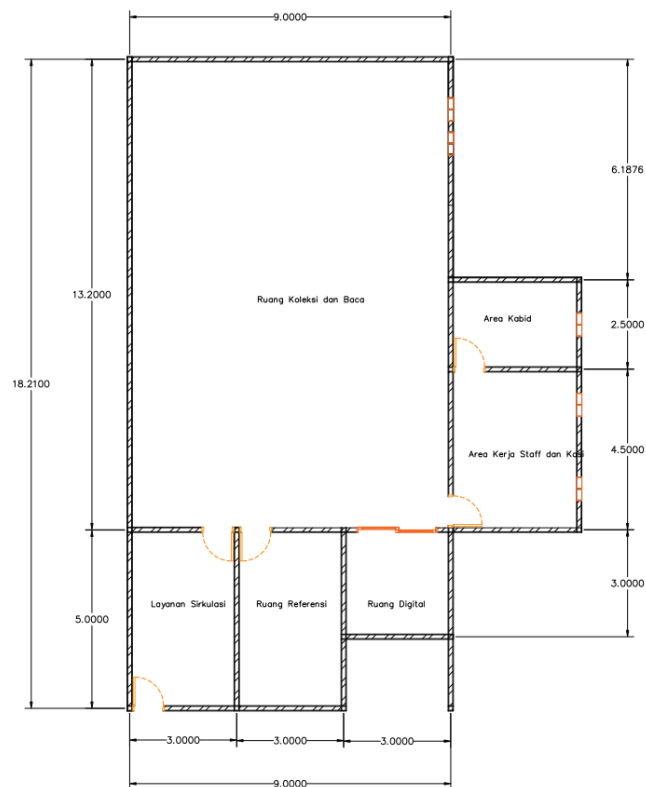


Figure 2: Batam city public library floor plan  
Source: Author, 2022

### 3. METHODS

#### Research Design

This research uses a quantitative descriptive method, with the descriptive method derived from primary data sources of measurement findings found in the field. This research uses a quantitative descriptive method, with the descriptive method taken from primary data sources of measurement findings in the field. This research uses a deductive and an inductive methodology, defining the phenomenon factually using the facts gathered during data collection and analysis. It does not take long for researchers to conduct this study; Researchers only need to visit the site once or twice to assess the state of the existing libraries.

The first step in this study's methodology is search for relevant references in the literature, which led to the identification of additional concerns with the existing situation. The following step is to gather data, both primary and secondary. The next step is to validate the data's validity so that the data utilized in this study can be shown to be valid. The researcher will next analyze the data to determine the solution to the current issue before making a conclusion. briefly shown in picture 3.

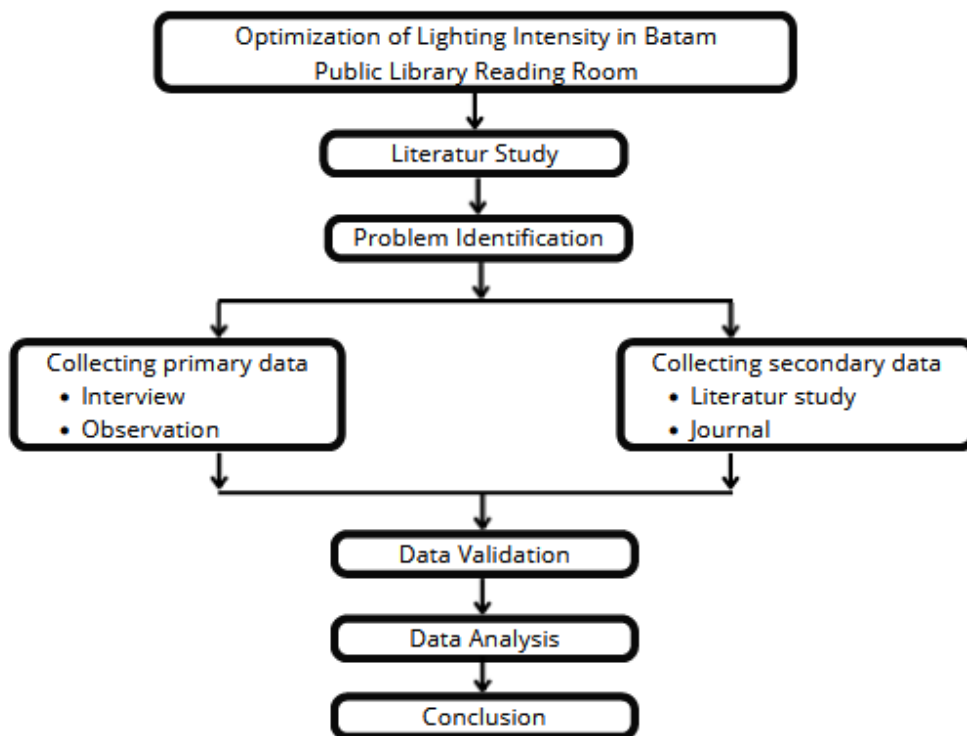


Figure 3: Research Flow  
Source: Author, 2022

#### Data Sources

This study relied on both primary and secondary data. Primary data is information collected directly from a source. The primary data for this study came from observations, questionnaires, and interviews. Meanwhile, secondary data is information collected indirectly. Secondary data for this study came from books, journals, and articles that were relevant to this research (Nurwanda & Badriah, 2020).

### **Data collecting methods**

Data collecting methods are strategies to gather information relevant to the conducted research. The strategies employed to collect data are directly related to the success of the research (Nurdiansyah & Rugoyah, 2021). The following data collection methods were employed in this research:

1. Observation is the technique of accurately finding data in a research. At this point, the researcher may see the object for analysis. In order to make their observation, the researchers had to participate in the environment actively they were looking for (Sugiyono, 2017). For accurate information, researchers directly watch the action that happens at the research site.
2. A questionnaire is a data collection technique that gives respondents several written questions according to usefulness (Widoyoko, 2016). This research used questionnaires to gather information on respondent's issues. In this research, random sampling was used as the method of sampling. Random sampling is the process of selecting sample participants at random without considering the degree of equality in the population (Sugiyono, 2017).
3. Interviewing is a process used to collect and complete data so that researchers can have accurate and precise data (Prasanti, 2018). In this research, researchers interviewed people who were competent in their respective. In this case, the resource people were the worker who worked in the registration section. Based on the interview, on average, only ten persons visited the library daily throughout the previous year. The majority of visitors are parents who bring their children to read.
4. A literature study is a method of collecting data from printed sources to complete the data in the research (Rahayu, 2018). For this research, researchers will search books and journals for a number of references about lighting comfort

### **Data validation**

Validation measures the degree of agreement between actual data and data found by researchers to determine the validity of anything (Sugiyono, 2017). The triangulation methodology was the researchers' choice for the data validation method in this research. A method for validating data is the triangulation technique, which involves using many methods to examine data from the same source (Sugiyono, 2017). The questionnaire method was employed in this study, and the technique was then triangulated using interviews.

### **Data analysis**

At this point, the researcher will evaluate the data in order to interpret the data derived from the research results. Researcher will then combine the current data and elaborate into conclusions that are consistent with the research conducted. Data will be analyzed and processed by researchers using the simulation software dialux evo.

## **4. RESULTS AND DISCUSSION**

The research was carried out in a public library on the fourth level of a join office building in Batam City. A room that will be examined in this research is the catalog and reading room, which is 118.8 m<sup>2</sup>. The following situations can be identified in the library's reading room and catalogue:

1. There are two different kinds of lamps in the form of downlight and LED light
2. 9 watt downlights and 18 watt LED lights
3. The number of light point is 8 downlights and 12 LED lights
4. Walls in a dark yellow colour
5. There are amenities like tables, seats, bookcases, and air conditioning in the room
6. Room height is 3 meters

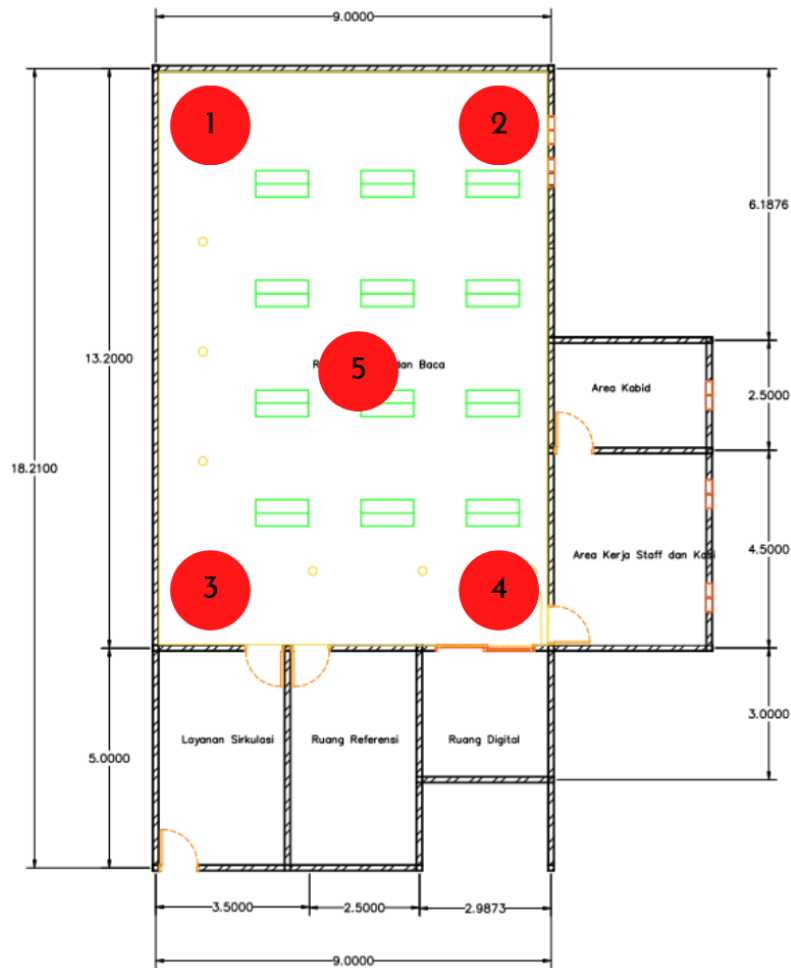


Figure 4: Batam city public library floor plan

Source: Author, 2022

Observations are conducted during the day using light sources such as natural lighting (sun) and artificial lighting (downlights and LED light). Measurements are taken at the five points shown in figure 4. The situation is when the lights are on, the furniture is arranged in such as existing condition, and no one else is nearby. Table 1 displays the measurements made using the lux meter.

**Table 1.** Light measurement using lux meters

	<i>SNi</i>	Spot 1	Spot 2	Spot 3	Spot 4	Spot 5
Light On	300 Lux	85 Lux	.750 Lux	26 Lux	.139 Lux	.118 Lux

The average point in the room did not reach the SNI criteria (300 LUX), according to the information in table 1. At point 2, the illumination intensity is impacted by sunlight that entering through the opening in the form of a 58 cm x 60 cm window, resulting in light intensity surpassing the SNI norm and producing glare for room users.

Next, to strengthen the data, researchers simulate reading rooms and catalogues with actual space conditions. As shown in figure 5, the simulation was performed using the dialux evo software. The first photo shows the state when a windows is active, and the second image shows the situation when it is not.

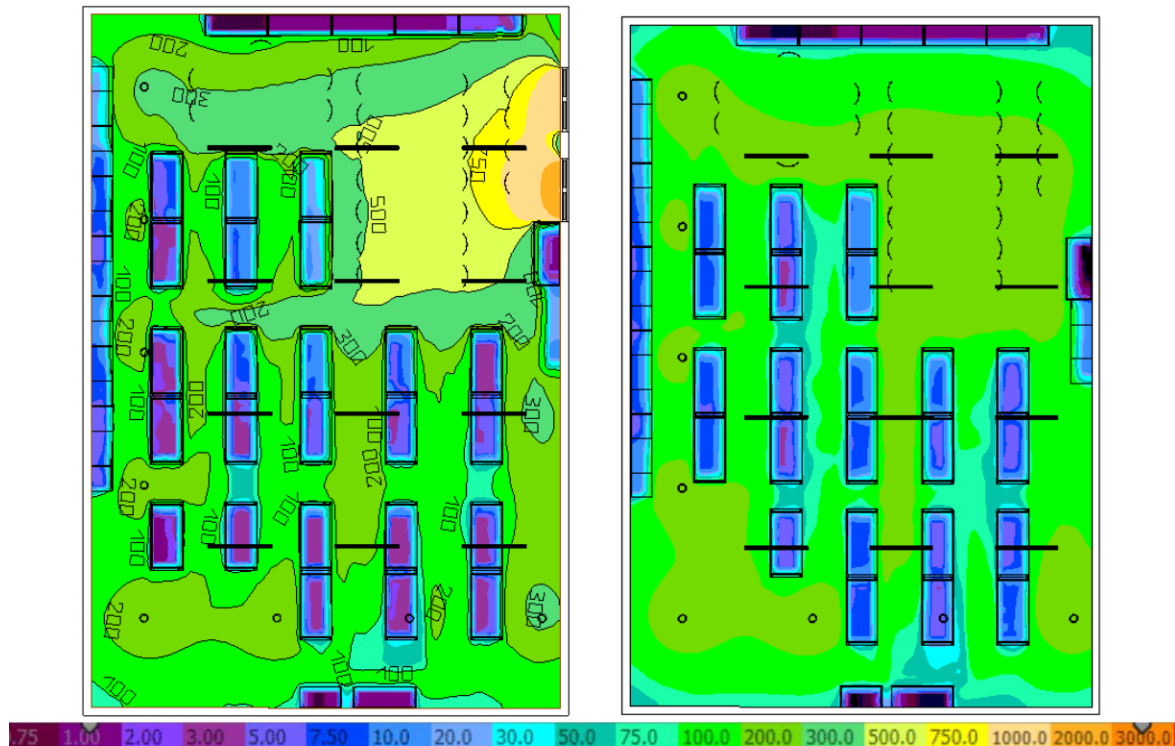


Figure 5: Calculation results of catalog room and reading room

Source: Author, 2022

The simulation findings using dialux evo and the results of direct measurements in the field are the same as showing that the lighting in the Batam City Public Library still does not satisfy the SNI standard (300 lux), so the data used in this research can be confirmed to be accurate. The first image shows the condition of the room when windows or other openings are used; sunlight can quickly enter the space, raising the light level above the SNI level (300 lux) and making it glaring for anyone sitting in front of the window. The window opening is not being used in the second image, the room is more comfortable when the opening is closed, but the light intensity still falls short of the SNI standard (300 lux). Therefore, simulations were run in this research without being aware of any existing openings.

Many factors, like the colour of the walls, the amount of lamp power utilized, the type of lamp used, the colour of the lamp, the arrangement of the furniture, the height of the ceiling, and others, have an impact on the quantity of light. In this research, the researchers did many analyses based on elements that affect light intensity to achieve a high light intensity in compliance with SNI criteria.



### Changing the color of the wall surface

The first experiment that researchers conducted was to modify the colour of the wall surface. Only the wall colour was changed in this experiment; the furniture arrangement, lighting configuration, and lamp power remained identical to the original situation.

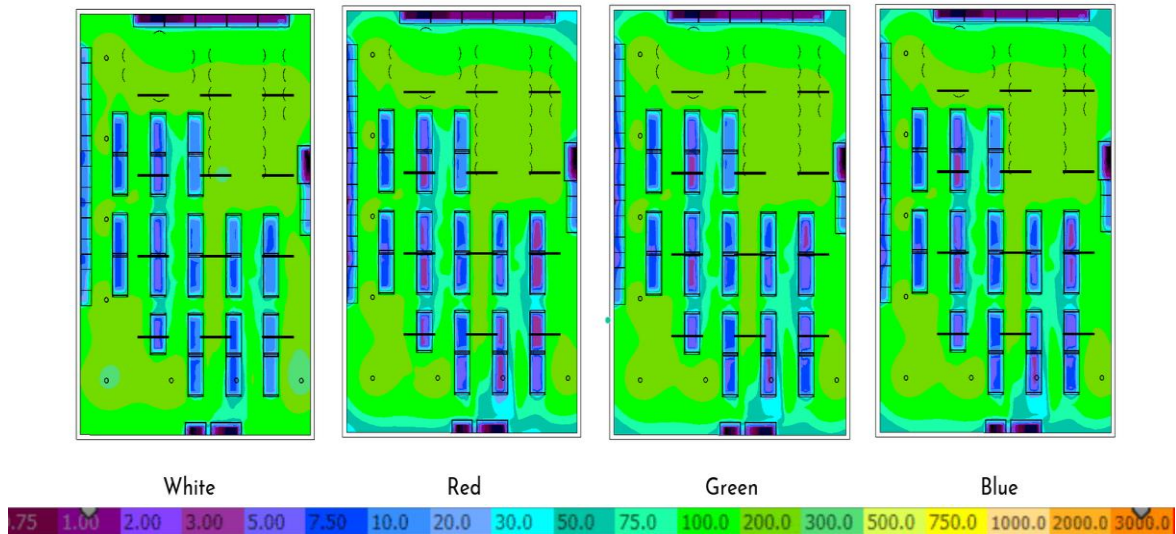


Figure 6: Lighting simulation by changing the color of the wall surface

Source: Author, 2022

The first experiment the researchers carried out involved painting the wall surface a variety of hues, including white, red, green, and blue. According to the simulation results, changing the colour of the walls in a relatively large room (at this case 13.2 m x 9 m) had no discernible impact, as seen in figure 6. White hue has a big impact on the space around the wall but has no effect at all in the centre of the room, whereas red, green, and blue wall surfaces do not even make a big difference. Therefore, the colour of the wall surface in a large room has little to no effect.

### Changing the furniture arrangement

The second experiment is to rearrange the furniture. The walls' colour, the lights' arrangement, and the lamps' power are all the same as they were in the existing area. The first experiment was carried out by changing the furniture layout in the direction of the lamp. In this first experiment, the spread of light became different, but the light intensity was the same from 100 lux to 200 lux. The second experiment was moving the bookshelf to the side of the room and the reading area to the middle, resulting in a significant impact on how the light was distributed throughout the space. However, the amount of light intensity does not satisfy the SNI standard (300 LUX). Even if some area of the reading room have 300 lux of light, the lighting is still unequal.

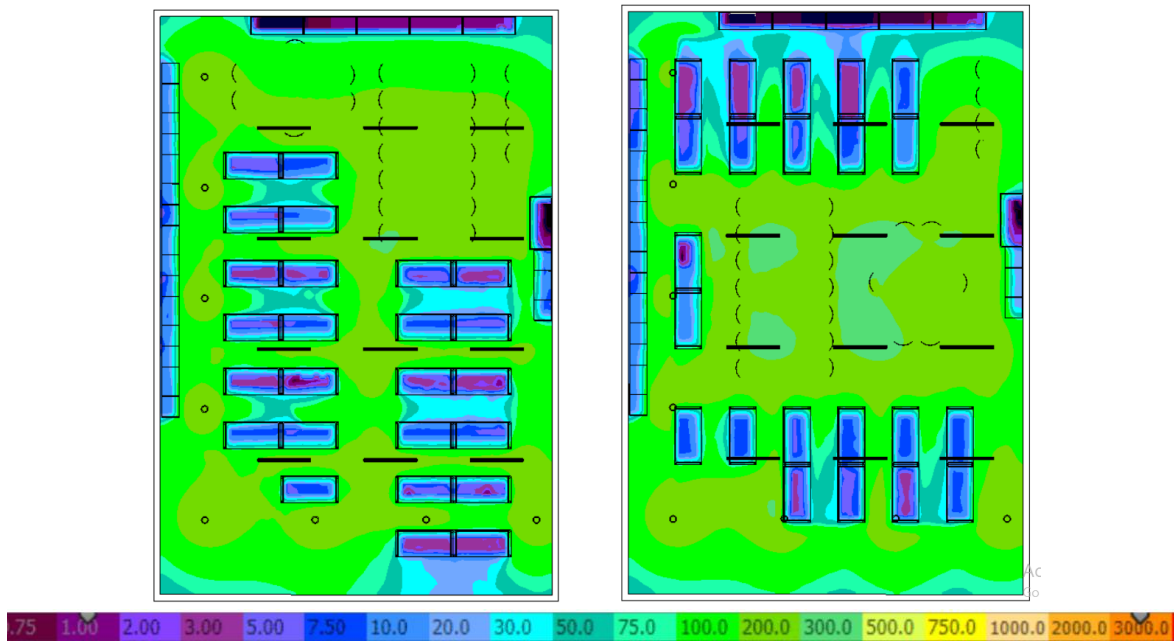


Figure 7: Lighting simulation by changing the furniture arrangement

Source: Author, 2022

The intensity of the existing light can be significantly changed by rearrangement of the furniture. The furniture's height and size have an impact on it. As seen in figure 7, the bookshelves significantly impact how the distribution of the existing light intensity changes. The spacing between pieces of furniture also has an impact on the illumination that already exists.

#### Changing the lighting arrangement

After experimenting with different wall colours and furniture arrangements, it was discovered that the amount of light intensity did not satisfy SNI criteria, especially in the front area of the window. Based on this, researchers tried to alter and add some lights in the third experiment, as seen in figure 8.

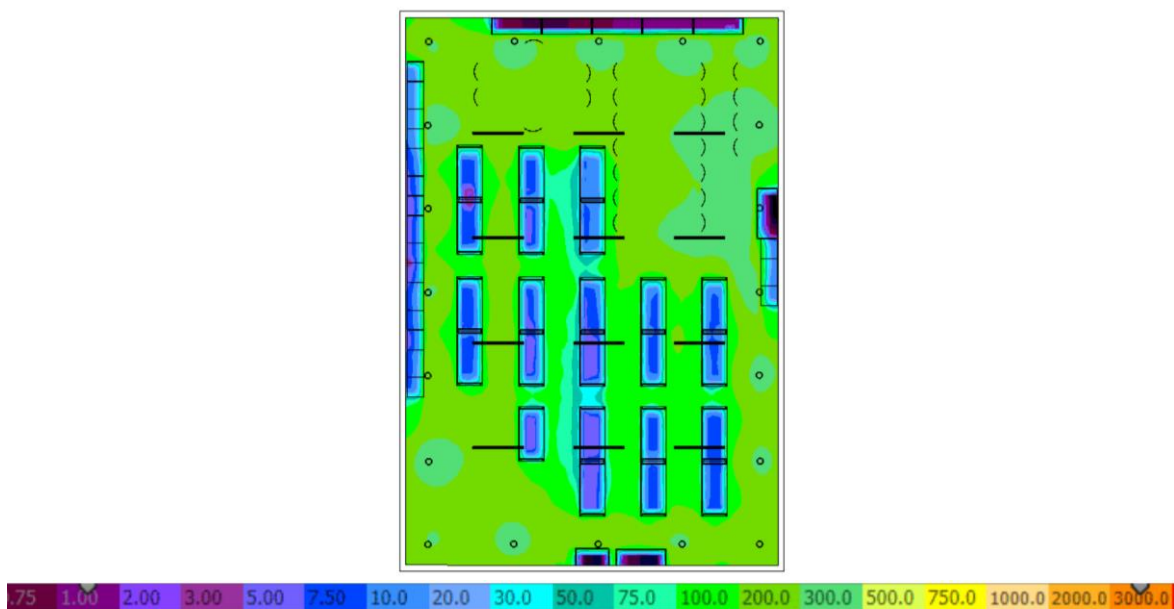


Figure 8: Lighting simulation by changing the lighting arrangement

Source: Author, 2022

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Downlight is a type of lamp used in this experiment. The researchers added light to the upper section near the opening and the right area. In this experiment, researchers raised the number of downlight spots from 8 to 20, with lamp power same as the existing situation (8 watt downlight and 18 watt LED). Especially on the front portion of the window, which did not change significantly in earlier experiments, the addition of these light spots had a significant effect. The spread of light in the space is still dominated by 100 lux to 200 lux, though some locations in the space have started to approach 300 lux.

### Replacing the wattage of the lamp

After three experiments without adjusting the lamp power, the reading room and catalogue room still need to satisfy the SNI standard (300 lux). Therefore, researchers are trying to increase the power of current lighting. Researchers increased the wattage of LED bulbs from 18 watts to 26 watts and downlights from 9 watts to 19 watts. Figure 9 shows the simulation results.

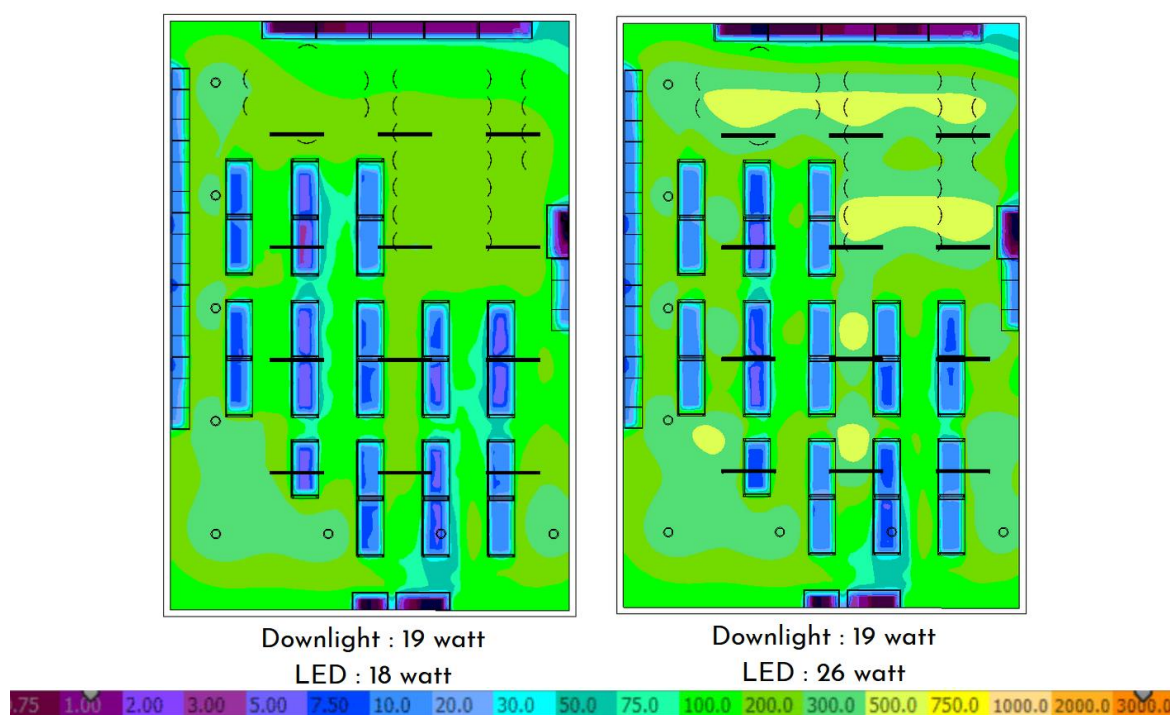


Figure 9: Lighting simulation by replacing the wattage of the lamp

Source: Author, 2022

The experiment was conducted with furniture and lamp settings that all the same as they were in the existing area. The downlight lamp's power was raised to 19 watts in the first experiment, while the LED still 18 watt. Although the reading room and catalogue illumination in this experiment did not meet the SNI requirement, it was better than in the prior experiment. The room is still dominated by a light magnitude of 100 lux to 200 lux, though the spread of light has sometimes reached 300 lux.

The second experiment was conducted by raising the downlight's power to 19 and the LED lamp's power to 26. In this experiment, the reading room has multiple locations where the glaring light intensity is higher than 300 lux. At some point, the 300 lux spread of light intensity started to increase, but it was distributed unevenly. Based on both experiments, the library's reading room and catalogue room still need to satisfy the SNI standard (300 lux) by increasing the lamp power.

### Changing the furniture arrangement and new lamp power

The next experiment was carried out by rearranging the furniture and increasing the lamps' power without changing the existing lights' layout. The experiment was conducted by moving the bookshelves around and making a gap between each cabinet. In this experiment, there was a one meter gap between each bookshelf. Guest reading areas were moved to the room's centre by tables and chairs.

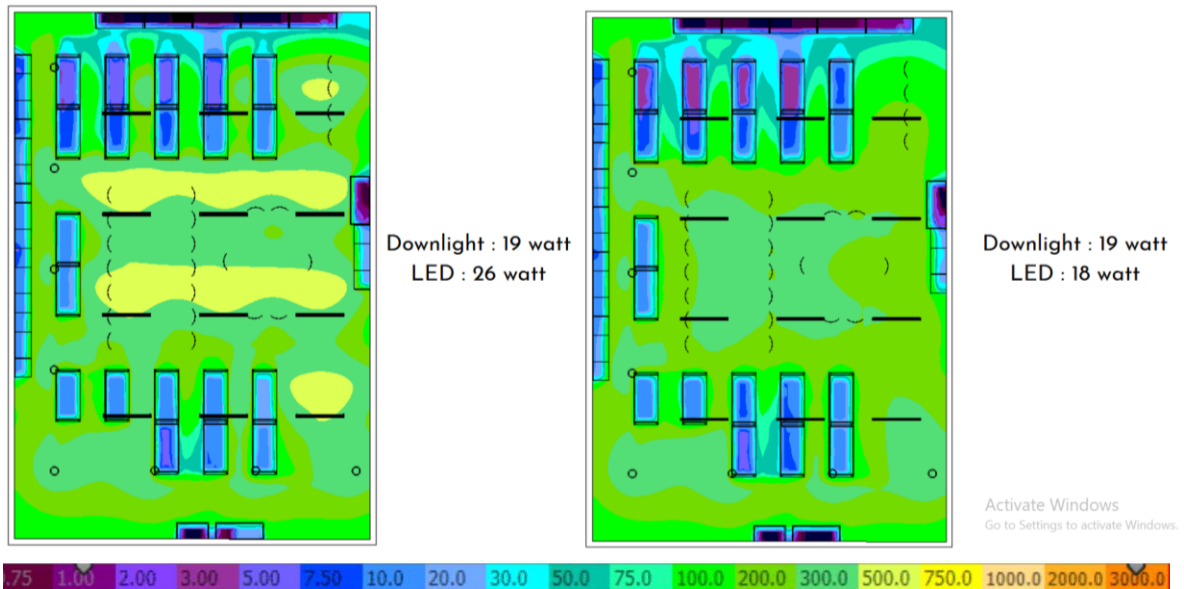


Figure 10: Lighting simulation by changing the furniture arrangement and new lamp power

Source: Author, 2022

The first experiment involved raising the downlighting lamp to 19 watts and the LED to 26 watts. The simulation results using dialux evo software show that in the reading area, the lighting intensity exceeds the SNI standard (300 lux), causing users feel glare when in the reading area. Several locations in the catalogue area have reached the SNI standard (300 LUX), but they are generally dominated by 100 to 200 LUX. The light intensity in the window area is also poor, ranging from 20 to 30 lux.

In the second experiment, the downlight was raised to 19 watts while the LED lamp was kept at 18 watts. The lighting intensity in the reading area in this experiment no longer exceeded the SNI standard and began to approach 300 lux, although unevenly distributed. Some areas in the catalogue area have achieved SNI standards, but most are 100 to 200 lux dominant. The light intensity in the upper part of the room is only between 20 and 30 lux, which is also insufficient.

### Changing the lighting and furniture arrangement

The simulation results from the previous experiment show that the portion of the room closest to the window needs more light intensity to satisfy SNI standards. This is because there is not enough lighting to cover the area. Adding light spots is the only way to provide adequate illumination for the room space. In this experiment, researchers increased the number of downlight points from 8 to 20, each containing a 19 watt downlight and an 18 watt LED light.

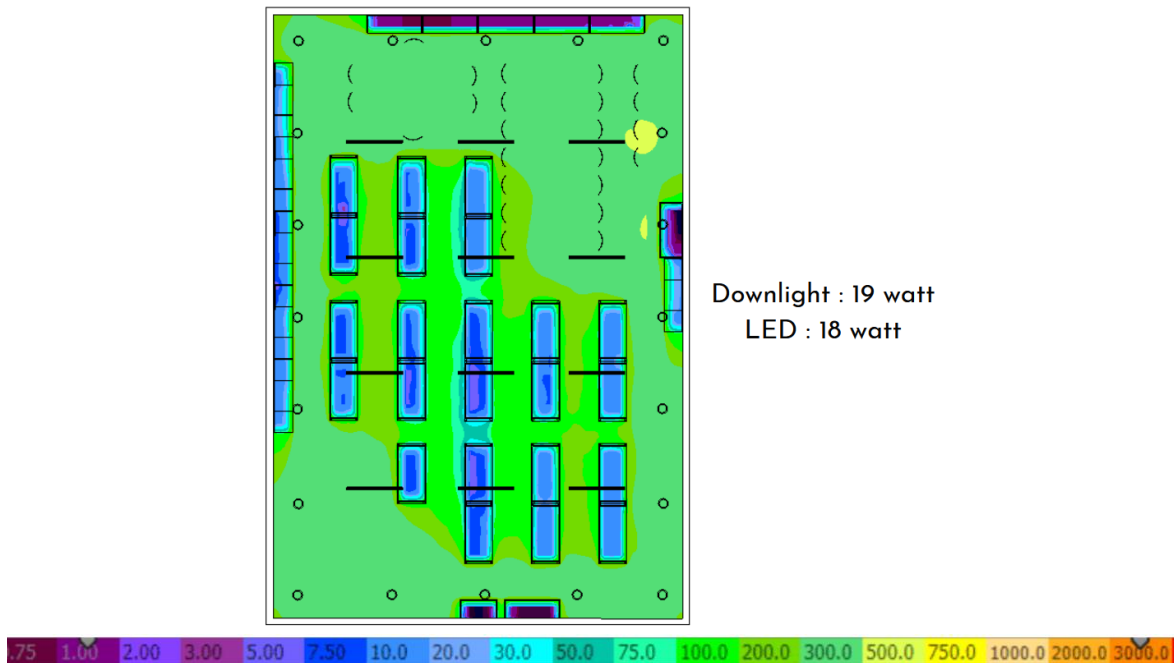


Figure 11: Lighting simulation by changing the lighting arrangement and lamp power  
Source: Author, 2022

The experiment was conducted using the same furniture arrangement as the original condition, and the simulation results showed that most of the rooms had achieved SNI standards. However, the lighting intensity in the large catalogue area was still at 100 lux. In the reading area, there was a point that exceeded the SNI standard, causing glare and making visitors uncomfortable.

The following experiment involved rearranging the furniture while using the new lamp configuration and lamp power. Especially in the catalogue area, which consistently receives a light intensity of 100 lux from previous experiments, furniture is arranged more distant to allow for the spread of light between furniture.

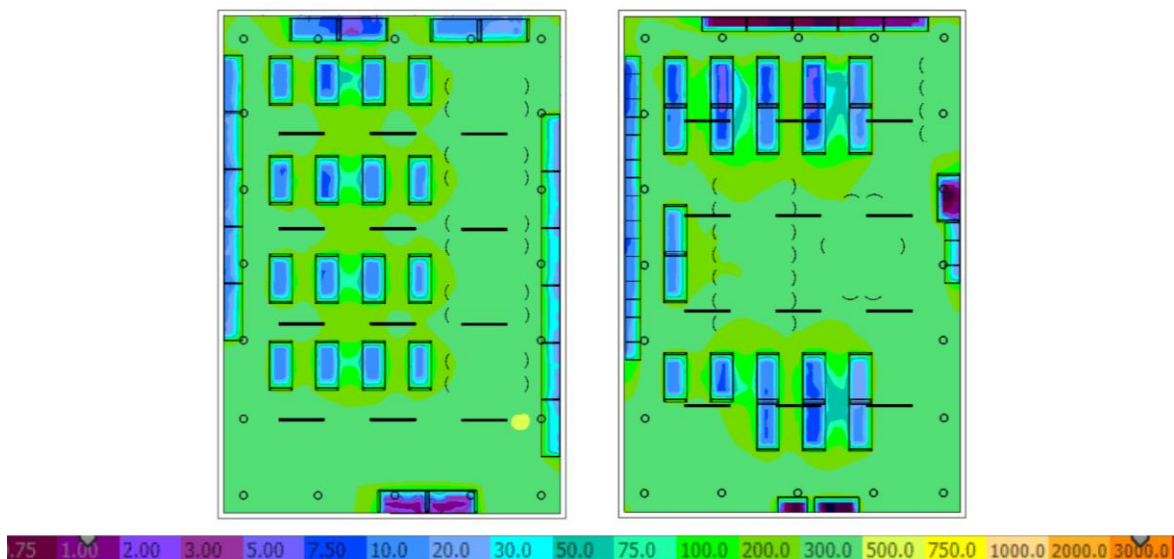


Figure 12: Lighting simulation by changing the lighting and furniture arrangement  
Source: Author, 2022

According to the simulation results in figure 12, the room's lighting was nearly balanced and satisfied the SNI standard (300 lux), especially in the reading area and the room's border, which in the previous experiment had difficulty receiving illumination. This simulation uses 12 lamp spot of 18 watt LED lights and 20 lamp spot of 19 watt downlights, with a one meter gap between each lamp.

## 5. CONCLUSIONS

Researchers might conclude that changing the colour of the wall surface in a large room does not significantly affect the distribution of light based on the outcomes of simulations performed using the dialux software. Additionally, the arrangement of the furniture and lighting has a significant impact on the distribution of light intensity.

The lighting of the Batam City public library does not exceed SNI requirements, particularly in reading rooms and catalogues. The following suggestions are made for the design of lighting that complies with SNI standards:

1. When simulating using the current conditions, there are some spots that cannot comply with SNI regulations, so changing the arrangement of the light point and adding numerous lights are required,
2. In order to comply with SNI requirements, the lamp wattage must be changed from original combination of a 9 watt downlight and 18 watt LED light to a 19 watt downlight and 18 watt LED light.
3. Changing the layout of the furniture, the layout of the furniture has a great impact on the intensity of the light around the furniture.

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