Evaluation of the lighting system in drawing studio at the E12 building, Faculty of Engineering UNNES

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Abstract. A room can be said to be a good one if the lighting following the requirements of needs depends on the function of the room. The room studied in this study was a drawing studio room in E12 Building, Faculty of Engineering UNNES. This room has a condition where the spread of light entering from the window is uneven so during the day the lights must always be turned on. The purpose of this study is to measure and evaluate the lighting intensity of the drawing studio space. This research was conducted using descriptive and evaluative methods. The data obtained is sourced from the results of direct light intensity measurements on the object of research conducted in the morning, afternoon, and evening for three days using a lux meter and measurements made referring to SNI 16-7062-2004 about measuring the intensity of lighting at work. The results of the measurement of lighting intensity in the image studio room will be compared with the SNI recommended standards. According to SNI 03-6575-2001, the standard requirement for a lux studio drawing space is 750 lux. The result, both when the lamp is turned on and the lamp turns off the measurement results do not meet the standards. It is recommended to increase the intensity of artificial lighting (lights) in the drawing studio until it meets the SNI 750 lux standard. From the results of calculations with the lumen method, it is recommended to replace each lamp with a lamp that has a light current of 9360 lumens.

1. Background
The success of an educational program is determined by several factors, namely students, educators, infrastructure, curriculum, funds, and other external factors. One of them is facilities and infrastructure in the educational environment, especially in Higher Education. Facilities are a supporting factor as educational facilities that are directly related to Teaching and Learning Activities such as stationery, teaching media (blackboards, teaching aids, etc.) while infrastructure is not directly related to campus buildings, fields, canteens, and so on. The provision of this infrastructure has been planned and has been budgeted from the Central Government.

One of the infrastructures in the Architectural Engineering Study Program is a practice room to support learning under the competency of expertise in the Study Program. In the Architectural Engineering Study Program, the required infrastructure is a picture studio. The drawing studio is a classroom for teaching and learning that is devoted to drawing activities. Therefore the main activity carried out in the drawing studio room is drawing, an activity that requires accuracy and focus.

The higher the accuracy of vision required, the higher the lighting required. Space studio image as a learning infrastructure requires sufficient lighting intensity to support the activities of its users.
However, excessive lighting is not good because it will cause glare or can even damage eye health. There must be lighting control when in conditions of excessive light intensity. According to SNI 03-6575-2001 [1], the ideal lighting needed for a room to draw is 750 lux. Lux is a unit used to measure lighting levels. The light that comes into the room comes from two sources namely natural lighting and artificial lighting. Natural lighting is light that comes from the sun while artificial lighting comes from light other than natural light, in this case, lights [2].

The object that will be examined in this study is the drawing studio room which is currently used as an Architectural Design Studio in the E12 Building FT UNNES 1st floor. This building consists of 3 floors with an L-shaped mass. This building has several rooms, one of which is various classrooms - multiple sizes with rectangular shapes, and most classrooms are enclosed in other classrooms. Several classes are facing east, north, and south. This allows the classrooms in this school to have different lighting intensities.

![Figure 1. Room Plan of Drawing Studio (TA Studio) 1st Floor of E12 Building FT UNNES](image)

Drawing Studio (see Figure 1) is located on the 1st floor east side of the E12 building with windows and entrances facing east and west. This room is rectangular (size 9.6 m x 7.8 m) with elongated sides north-south, elongated sides (west-east) there are doors and windows while north-south sides have no windows. Although there are two sides with windows, the light entering through the window is not spread evenly. During the daytime, the lights in both the southern and northern regions must always be turned on.

From the background above, the writer formulated the problem which was elaborated in the form of a question, What is the description of the lighting conditions of Drawing Studio in E12 Building FT UNNES? and What are the results of the evaluation of the lighting conditions in Drawing Studio in E12 Building FT UNNES?

The objectives of this research are as follows: 1) Knowing the lighting conditions of Drawing Studio in E12 Building FT UNNES?, 2) Knowing the results of the evaluation of the lighting conditions of Drawing Studio in E12 Building FT UNNES?
2. Natural Lighting
Natural lighting is light that comes from the sun. Natural lighting is needed because humans need the quality of natural light. The natural lighting function can minimize the use of electrical energy. So that designs that prioritize the use of natural lighting must be developed.

Ander [2] explained several design strategies for natural lighting, including increasing the circumference of natural lighting zones, penetration of natural lighting above the room, use of the idea of "effective opening" for initial estimates in the optimal glass area, the reflection of natural lighting in space to increase room brightness, avoidance of direct exposure to natural light in areas of critical visual tasks, careful use of direct light in areas where noncritical work takes place, and natural lighting filtering.

3. Artificial Lighting
Artificial lighting is lighting produced by light sources other than natural light. Artificial lighting is very necessary if the position of the room is difficult to achieve by natural lighting or when natural lighting is inadequate [3-5]. Karlen and Benya [6] explain in full about step by step to get a good artificial lighting design, namely:
   a. Step 1: Determination of lighting design criteria. Several criteria cover the quantity and quality of lighting, which ensures that you design lighting to produce the right amount of light, namely 1) the quantity of lighting, 2) the quality of lighting, 3) Energy coding
   b. Step 2: recording architectural conditions and boundaries
   c. Step 3: visual assignment and work to be served
   d. Step 4: choose the lighting system to be used

4. Image Space Lighting Requirements
Lippsmeier's stated that the intensity of sunlight and the reflection of strong sunlight are symptoms of a tropical climate [7]. So it is necessary to design related to the material and color of the furnishing layer elements of space. According to the National Standardization Agency (2001), testing natural lighting during the day is intended to test or assess/check the natural lighting conditions during the day. According to SNI 03-6575-2001, the ideal lighting needed for a room to draw is 750 lux. Lux is a unit used to measure lighting levels [1].

5. Research methods
The method used in this research is descriptive and evaluative methods. A descriptive method was used in the initial research to collect and present data on existing conditions. Evaluative methods are used to evaluate the research data obtained.

Descriptive research is not intended to test certain hypotheses but only describe "as is" about a variable, phenomenon, or condition [8]. The descriptive method is a research method that tries to describe and interpret objects according to what they are. The purpose of this descriptive study is to make a systematic, factual, and accurate description of the facts and properties of a population [9].

According to Sukmadinata, evaluation has two main activities, namely measurement or data collection, and comparing the measurement results and data collection with the standards used. Based on the results of this comparison, it can only be concluded that a program, activity, or product is feasible or not, relevant or not, effective or not, and whether or not it is efficient [10].

The location of this research is in E12 Building, Faculty of Engineering, Universitas negeri Semarang (UNNES) Sekaran Campus, Gunungpati, Semarang. The time of the study is from May to October 2019. In May the authors make a proposal. In June, the time and measurement points were determined. From June to July measurements are taken, data collection in the field, to data analysis. When the lighting measurements are carried out in June-July 2019. Based on the solar diagram, in June-July the distance of the earth and the sun is farther than in March or September. So that month, Indonesia was experiencing a dry season.
Variables are observable characteristics of an object. The variable in this study is the Evaluation of Lighting Drawing Studio of Building E12, FT UNNES, with the following indicators:

1. Dimensions and orientation of openings at the study site
2. Building orientation and the direction of sunlight
3. Measurement of natural lighting levels
4. Measurement of artificial lighting levels

Based on SNI 16-7062-2004 [11] regarding the measurement of lighting intensity, determining the measurement point can be used through two ways, i.e. based on local lighting and general lighting. Local lighting is lighting in the place of work object, either in the form of a work table or equipment. Whereas public lighting is lighting in all work areas. Measurements are made by determining the intersection points of the horizontal length and width of the room at any given distance from the entire work area. The distance between points is based on the size of the room to be examined.

In this study using a local measurement method that is measurement is carried out on the work object. The work object here is the drawing table. Measuring instruments are placed on the work table and then the numbers that appear on the panel screen. Not all work fields are used as measurement points and adjust to the conditions of the room.

The time of measurement will be carried out starting from 07.00 until 17.00 WIB. This is based on the time spent on the learning process at FT UNNES. The room will be measured at six measurement times with a two-hour interval, which is at 07.00, 09.00, 11.00, 13.00, and 17.00. Data obtained from the measurement results will be recorded in the table.

The results of the lux meter measurements will be compared with the standard lighting drawing studio space of 750 lux based on SNI. Research data are presented in tables and diagrams.

The analysis is done after the research data is collected completely then the data is analyzed and processed to produce conclusions.

The type of approach used in this research is a quantitative descriptive approach. After all field data has been collected through lux meter measurements and observations, the data already obtained will be compared with room lighting standards based on SNI 03-6197-2000 [12]. The research data are presented in the form of figures and tables which are then analyzed and described.

**Table 1. Research procedure**

| No | Research Stage       | Details                                                                 |
|----|----------------------|------------------------------------------------------------------------|
| 1  | Planning Phase       | • Determine the measuring points to be studied                           |
|    |                      | • Planning research time                                               |
|    |                      | • Prepare research tools                                               |
| 2  | Measurement Phase    | Measurements were made at several points in the drawing studio of Building E12, FT UNNES |
| 3  | Data Processing Stage| • Collection and processing of data regarding the existing conditions of measurements that have been carried out |
|    |                      | • Analysis of lighting fulfillment standards                            |
6. Results And Discussion

The measuring point is determined based on the provisions of SNI No. 16-7062-2004 concerning the measurement of lighting intensity [11]. Because lighting in the Drawing Room of Building E12 includes general lighting, the measurements follow the provisions:

1). The intersection of the horizontal line length and width of the room at any given distance as high as one meter from the floor.

2). The area of the room is less than 10 square meters: the intersection point of the horizontal line length and width of the room is at a distance of every 1 (one) meter.

3). Considering the building is finished, the measurement point is based on usage.

4). Measurement at the measuring point in the inclined table position (drawing position)

Plan of measuring points for general lighting intensity for Drawing Room Building E12 as shown in Figure 2.

![Figure 2. Room conditions in the light off](image)

The results of measurements in space when the lights are turned off are shown in table 2.

| Date and time | July 25, 2019 |
|---------------|---------------|
| Measuring point | Measurement Time (LUX) | Standards based on SNI (LUX) | Meet the Standards (Y / N) | Information |
| 1, 4, 8, 10, 2, 14, 16 | 10 | 10 | 750 | N |
| 3, 9, 13, 15, 17, 18 | 5 | 5 | 750 | N |
| 5, 11 | 5 | 10 | 750 | N |
| 6 | 80 | 40 | 750 | N |
| 7 | 5 | 40 | 750 | N |
| 12 | 80 | 40 | 750 | N |
| Outer Space East Side | 80 | 225 |
| Outer Space West Side | 40 | 80 |

In Figure 3, it is shown the condition of the room in the state of the lamp turns off, in this condition the lighting is very less where the results of measurements in table 2 show that the highest value is 80 lux, still below the required standard of 750 lux.
The results of measurements in space when the lights are turned on are shown in Table 3.

**Table 3. Lux Meter Measurement Results (Live Light)**

| Measuring point | Measurement Time (LUX) | July 25, 2019 | Standards based on SNI (LUX) | Meet the Standards (Y / N) | Information |
|-----------------|------------------------|---------------|-------------------------------|---------------------------|-------------|
|                 | 09.00-10.00            | 12.00-13.00   |                               |                           |             |
| 1               | 40                     | 40            | 750                           | N                         |             |
| 2               | 120                    | 225           | 750                           | N                         |             |
| 3,4,5,8,9,10,11,14,15,16,17 | 225                 | 225           | 750                           | N                         |             |
| 6,7,12,13,18    | 80                     | 80            | 750                           | N                         |             |
| Outer Space East Side | 80                  | 225           |                               |                           |             |
| Outer Space West Side | 40                 | 80            |                               |                           |             |

In Figure 4 shows the condition of the room in a state of lamp life, in this condition (with a total of 12 lamps @ 19 watts) lighting is still lacking where the results of measurements in Table 3 show that the highest value is 225 lux, still below the required standard of 750 lux.
All measurements at the measuring point, both when the lamp is turned on and off, the results do not meet the standards according to SNI, namely 750 Lux. At the time of the lamp turns off, the highest intensity is 80 Lux, while at the time of the lamp's turns on, the highest intensity is 225 Lux.

7. Conclusion

Studio rooms that were studied both when the lights were off and the lights were on did not meet the SNI requirements of 750 lux. So the space is not feasible to be used as a picture studio. The current condition of the space is used for the Architectural Design Studio, wherein the task there are two stages, namely making concepts and designing, where before starting to draw, students make draft concepts and designs using manual methods through scribbles on paper. So that for these two stages lighting conditions are inadequate.

8. Suggestion

It is recommended to increase the intensity of artificial lighting (lights) in the image studio room until it meets the SNI 750 lux standard.

The existing condition of the space is 9.6 m x 7.8 m (74.88 m²) with a total of 12 lamps @ 19 watts.

To get the required lighting value (E) of 750 lux, a recalculation is necessary.

Wanted: How many currents of light (lumens, Fi) of each lamp (out of 12 lamps) so that the illumination strength (E) as required (750 lux)

The formula used [13]:

\[ NF_i = \frac{E \times A}{K_p \times K_d} \]  

where

Fi = Light of a lamp (lumen) ------?
E = Lighting Strength (Lux) ------- 750 lux
A = Room Size (m²) ----------- 74.88 m²
N = Number of Lights ---------- 12 pieces
Kp x Kd = Coefficient of use x depreciation coefficient = 0.5

So from the 12 lights available, each must be replaced with a lamp that has a minimum light current value of 9360 lumens to achieve the required lighting strength of 750 lux.

References

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