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Analysis of Classroom Light Intensity as an Indicator of Effects of Eyestrain in the Effectiveness of the Learning Process at the Universitas Muhammadiyah Lamongan

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Abstract

Eye fatigue may be brought on by the room's inappropriate lighting level. Classroom lighting is one of the physical aspects of learning that can impact how well students learn. The University of Muhammadiyah Lamongan has never reviewed the amount of light present in classrooms, nevertheless. Therefore, in this study, we brought up the issue of the connection between the classroom's light intensity and the measure of the impact of eye tiredness on the efficacy of learning at Universitas Muhammadiyah Lamongan. Based on a review of the outcomes of mapping light intensity in classrooms at the Universitas Muhammadiyah Lamongan, this study intends to ascertain the impact of room light intensity on eye fatigue in students as well as review classroom facilities. Analytical observation is the research methodology used. The information was gathered using a questionnaire about using a lux meter to measure light intensity and creating two- and three-dimensional contour maps of the distribution of light intensity in classrooms. Following the collection of data from the two processes, the data was examined to determine whether the respondent survey results and the light intensity contour map data could be correlated based on the respondent's seat in the classroom. Students that were enrolled in classes at Universitas Muhammadiyah Lamongan were the respondents. According to the study's findings, Muhammadiyah University Lamongan's class A302 experiences eye tiredness as a result of the low light intensity levels in the space, which range from (56,16 ± 0,32) lux and (69,93 ± 0,92) lux. If the light intensity value is greater than (69,93 ± 0,92) lux and is evenly distributed among all coordinate locations, which are the points where students are seated during lecture activities in class A302, the weary eye effect will vanish. According to this study, there is a connection between eye difficulties, the existence of curtains, the number of windows, the presence of a blackboard, the orientation of the classroom, and the postures in which pupils are seated and the consequences of eye strain. It is advised that classrooms at Universitas Muhammadiyah Lamongan increase the number of lights so that the lighting intensity ranges from roughly 300 to 500 lux. This will ensure that the interior lighting is of high quality.

Keywords: eye fatigue; light; intensity.

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INTRODUCTION (10%)

Light is one of the electromagnetic waves that can be produced by converting electrical energy into energy visible to the human eye (Hajibabaei et al., 2014). When the eye is focused on a close object for an extended period of time, eye strain can occur. This happens because focusing on close objects requires more effort from the eye muscles. This issue is exacerbated by inadequate lighting as well (Kuwahara et al., 2022). Eyestrain is influenced by environmental and work-related factors (Kurniawati et al., 2019; Yang & Moon, 2019). While illumination is an environmental component, age and eye problems are labor-related factors (Tanzila & Arista, 2023).

One factor that affects how well-designed the physical environment is for learning is the illumination intensity (Magero et al., 2023; Viula et al., 2023). Rupp et al. (2023) assert that the lighting in the classroom is there to spotlight the objects that are used as teaching aids. With sufficient and effective lighting, a welcoming and safe learning environment can be produced (Khalilpour et al., 2022).

Humans require light to detect objects visually, and the eyes, nerves, and visual nerve centers in the brain are the organs that have an impact on vision (Pain, 2005). The primary gateway for allowing images from the outside world into the visual system is the eye (Sayed & Abdallah, 2023). Visual acuity is necessary for about 90% of human labor tasks, including learning . Humans' eyes directly interact with their environment while performing tasks in order to see objects (Putra et al., 2021). Learning occurs in 83% of vision, in which impaired vision causes reduced educational effectiveness (Jafari et al., 2023).

As of now, learning activities at the Universitas Muhammadiyah Lamongan have been conducted in compliance with institutionally established operational standards as well as other legally enforceable guidelines for learning standards at the higher education level. The infrastructure and learning facilities in the immediate area, however, have never been reviewed. The amount of light present in space serves as the study's environment. At Muhammadiyah Lamongan University, research was done on the examination of classroom light intensity as a predictor of the impact of weary eyes on the effectiveness of the learning process. With a focus on comfort and safety, this evaluation seeks to create the optimal, effective, and efficient learning system (Anggraeni et al., 2023; Kurniasih et al., 2019; Putra et al., 2021).

On the other hand, the amount of light in the room has a significant impact on how well students and lecturers can see physically (Khalilpour et al., 2022; Rupp et al., 2023; Toftum & Clausen, 2023; Viula et al., 2023). In order to determine how eye tiredness affects the effectiveness of the learning process at the Universitas Muhammadiyah Lamongan, research is required to look at the intensity of classroom light. According to the role of the room, educators, managers, designers, and maintenance teams at educational institutions need to pay more attention to how interior spaces in universities are lit (Magero et al., 2023). Because the assessment of discomfort lighting and glare in buildings is an important parameter for checking accurate and conscious daylighting design for student’s health and studying efficiency (Pierson et al., 2017; Sun et al., 2020; Torres & Lo Verso, 2015) .

METHODS (15%)

Studying the visual conditions of respondents who use the space and creating a contour map of the distribution of light intensity in class A302 at the Universitas Muhammadiyah Lamongan are two methods used to analyze classroom light intensity as an indicator of the effect of eye fatigue on the effectiveness of the learning process. Following the collection of data from the two processes, the data was examined to determine whether the respondent's survey results and the data from the light intensity contour map were correlated based on where the respondent was seated in the classroom.

Age, gender, visual condition (visual impairment), sitting posture in class, classroom lighting environment, visual visibility in class, and degree of eye tiredness are some of the criteria questions included in the survey method for the visual condition of respondents using classrooms. The Google form, which was made available to a variety of class users during the study's semester, was used to collect all survey data.

The following technique involves creating a contour map of the light intensity distribution in University of Malaysia Lamongan's class A302. This method involves taking field measurements as a baseline before creating contour maps. The amount of light intensity (Lux) in the classroom serves as the necessary field measurement data. With the Aneng GN201 luxmeter (Figure 1) and rollmeter to measure light intensity, proceed as follows:

1. Measure the room's dimensions with a rollmeter, then divide it into grid coordinate points with a distance of 60 cm between each one;
2. use the Luxmeter height parameter to measure the intensity of light at each coordinate point from the floor up to the student's eye level while they are seated, measurements are carried out by carrying out repeated measurements because there is no comparative data or calibrator; and
3. record the light intensity data at each coordinate and use it to create a light intensity contour map.

Figure 1. Aneng GN201 Luxmeter

To ascertain the relationship between light intensity and outdoor lighting conditions and their impact on respondents, respondent survey data and contour map data were combined with regard to sitting posture.

RESULTS AND DISCUSSION (70%)

Comfort in the classroom and learning environment depends on the indoor quality of this environment, which is assessed based on certain parameters such as light intensity (Osemudiamen & Stanley, 2023). Data from studies employing the respondent survey method to analyze classroom light intensity as a measure of the impact of eye tiredness on the efficacy of the learning process are presented in Table 1.

Table 1. *Characteristics of Respondents*

Characteristics of Respondents		**Respondents**	
		N = 35	**%**
Age	15 – 20 yr	24	68,6
	21 – 25 yr	11	31,4
Gender	Male	7	20
	Female	28	80
Visual impairment	Yes	11	31,4
	Not	24	68,6
Type of Visual Impairment	Myopia	8	22,8
	Hyperopia	2	5,7
	Astigmatism	1	2,8

There were 35 respondents (N), all of them were students who regularly attended classes. The characteristics of the respondents match those posed in the survey questionnaire to identify students with visual impairments, which can be utilized as a starting point for the impact of tired eyes if the space lacks an effective lighting system. Students with normal eyes can also experience the consequences of eye fatigue, but students with visual impairments will experience these effects more noticeably. Because the eyes will be able to adjust to the light environment more readily and also deal with other visual disturbances like nearsightedness. A nearsighted person will exert additional effort to focus on distant and dim things if the light source is very faint, which leads to weariness more quickly than in persons with normal vision.

Figure 2. 2D design of classroom A302 Universitas Muhammadiyah Lamongan

However, using data on light intensity in the classroom as the basis for the quantity to support this hypothesis, the aforementioned first premise still has to be validated. By measuring the classroom's area and visualizing it as a spatial layout, as illustrated in Figure 2, the process of gridding, or creating coordinate points, is carried out in order to measure the amount of light in the classroom. The task of measuring and visualizing the conditions of the room is greatly aided by the spatial design. And don't forget to have a 3D design on hand to locate objects in the classroom in three dimensions, as shown in Figure 3.

Universitas Muhammadiyah Lamongan's classroom A302 has an area dimension of of 59.23 m^2 and specific measurements of 697 cm in width and 888 cm in length (Figure 2). The classroom A302 is then shown in three dimensions from the two-dimensional image (Figure 3). There are four small windows on the left side of the room, making the classroom corridor darker than the classroom, and closed room doors during class. There are three large windows on the right side of the room that have blinds that are closed to dim the light coming from outside. So the indoor lighting decreases gradually as the window transmission decreases. The presence of windows in a room affects lighting (Sun et al., 2020; Yu et al., 2022). The only source of lighting in room A302 is a light bulb, as can be observed from the data.

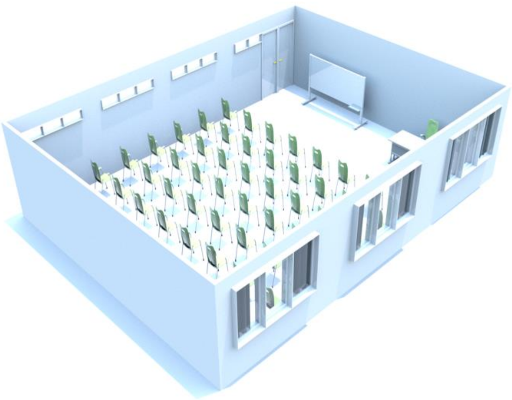

Figure 3. 3D design of classroom A302 Universitas Muhammadiyah Lamongan

The light intensity measurement is carried out using the predicted coordinates of the measurement spots on the A302 classroom layout once the plan has been viewed in three dimensions (Figure 3). A luxmeter is used for the measuring process, and it is positioned at a height that is equal to the height of the sitting human eye (Salehuddin & Latupeirissa, 2017; Tanzila & Arista, 2023). By making this modification, the instrument's measurement of light intensity will match the eye's measurement of light intensity. This is necessary because the distance from the light source will also affect the lux value because the photon intensity of light falls as a unit squared in spherical coordinates (Tanzila & Arista, 2023; Viula et al., 2023; Winterbottom & Wilkins, 2009). Figure 4 depicts the spatial measurement model.

Figure 4. Finding the coordinates of the measurement spots using a retrieval technique for spatial light intensity data (left) and the measurement process (right).

All data is gathered with x, y, and z coordinate values after subsequent measurements are made based on the measurement coordinates, where x denotes the column, y the row, and z the amount of light. In front of the classroom, the columns and rows represent measurement position data moving horizontally (from left to right) and from front to rear, respectively. The collected data is then transformed into a contour map, as seen in Figure 5. In order to make it simpler to conduct additional analysis, the contour map has been added to the classroom plan layer.

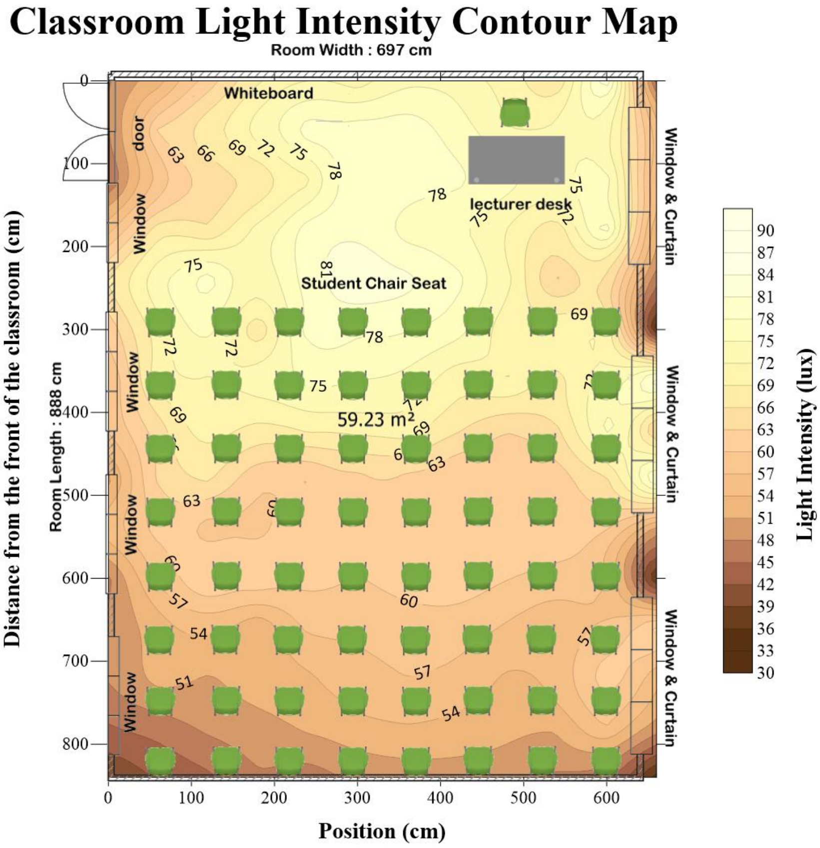

Figure 5. Light Intensity Contour Map in Room A302 Universitas Muhammadiyah Lamongan

Based on the contour map of the light intensity in room A302 (Figure 5), it can be deduced that the light intensity ranges between (33,96 ± 0,93) lux and (83,33 ± 0,72) lux when the measurement is taken with the light bulb on, the window covered by a curtain, and the classroom door closed. The front of the class, specifically the front row seats, the lecturer's desk, and the right side of the chalkboard, has the largest concentration of light. Due to the brown curtains, which can absorb a lot of light intensity but not as much as black or other dark colors can, some light can be seen coming from behind the window, but its intensity value is not very high. This works really well. The light intensity varies from (39,36 ± 0,09) lux to (51,43 ± 0,08) lux while getting dimmer toward the back of the student seat. The classroom corridor is darker than the outdoor corridor, therefore there is little light coming in via the little window to the left of the room. The survey information in Table 2 on the respondents' visual attributes was then correlated with the contour map data.

Table 2. *Characteristics of Respondents' Vision*

Sight Character		**Respondents**	
		N = 35	**%**
Illumination	Bright	27	77,1
	Not Bright	8	22,9
Visibility (Clear)	Clear	31	88,6
	Not Clear	4	11,4
Eye Fatigue	Tired	15	42,8
	Slightly Tired	10	28,6
	Not Tired	10	28,6

The visual features of the respondents only highlighted the importance of visibility and illumination (the degree of object clarity when viewed in class, whether written or other learning items), as well as any signs of eye tiredness or pain. According to the respondent's data, students with eye tiredness above 42.8% have traits that, when coupled to them, result in eye fatigue above 71.4%. The % value of visibility and room lighting can be used to identify the root of tired eyes. When the light exposure is too high or too low, the ocular nerves become disturbed, which causes signs of tired eyes to appear (Viula et al., 2023; Winterbottom & Wilkins, 2009), visibility and illumination have a specific amount of an impact on the response. Analysis of the light intensity data in room A302 from the viewpoint of the student's sitting position while in the space is still required. As a result, it needs to be tied to how the student is seated in order to convert the survey response into what the student's eyes are experiencing (Table 3).

Table 3. *Correlation of room light lux with visual characteristics from the highest to the lowest lux level*

No.	**Karakteristik Penglihatan**	**N Sample**	**Average Lux**
1.	Not Tired	10	69.1
2.	Bright	27	67.6
3.	Clear	31	67.4
4.	Tired	15	66.6
5.	Slightly Tired	10	65.7
6.	Not Bright	8	65.1
7.	Not Clear	4	64.3

Eye fatigue is also affected by the mechanism of accommodation. The mechanism of accommodation is a mechanism that focuses on eye lens systems that are important for high-grade vision acuity. Accommodation is due to the contraction or relaxation of ciliary muscles, in which the contraction causes increased lens system strength and relaxation leading to a reduction in lens strength (Kurniawati et al., 2019). Accommodation is the process of increasing the curvature of the lens. In the resting state, the tension of the lens is maintained by the pull of the lens ligament. Because the lens material is easily shaped and the lens capability of the capsule is quite high, the lens can be pulled into a sprawl (Kurniawati et al., 2019; Kuwahara et al., 2022).

The highest average lux value according to the student's sitting position was 69.1, and the sensation of visibility was reduced at the lowest average lux value, which was 64.3, according to the correlation table of room light lux with the visual characteristics of the lux level (Table 3). A slight adjustment in lux value is all that is necessary to influence how student vision is affected. The level of eye fatigue is at the recorded middle median lux, or 66.6, meaning that the eye response is on the edge of low lux. In order to understand that student eye tiredness is brought on by a drop in light intensity, which leads to a lack of room illumination, it was seen that the visibility of the learning materials in the classroom was declining. When this happens, the eyes will adjust quite aggressively, which makes the optic nerves work more diligently to get information regarding object clarity. The eyes will constrict more as a result and get tired more quickly. Table 4 examines how eye tiredness affects different combinations of optics because Table 3's characteristic data is insufficient to demonstrate this.

Table 4. *Correlation of room light lux with a combination of visual characteristics from the highest to the lowest lux level*

No.	Combination of Visual Characteristics	N Sample	Average Lux
1.	Bright, Clear, Not Tired	10	69.1
2.	Not Bright, Clear, Tired	3	67.6
3.	Bright, Clear, Slightly Tired	8	67.4
4.	Not Bright, Not Clear, Tired	3	66.9
5.	Bright, Clear, Tired	9	66.2
6.	Not Bright, Clear, Slightly Tired	1	61
7.	Not Bright, Not Clear, Slightly Tired	1	56.5
8.	Not Bright, Clear, Not Tired	0	0
9.	Bright, Not Clear, Tired	0	0
10.	Bright, Not Clear, Slightly Tired	0	0
11.	Bright, Not Clear, Not Tired	0	0
12.	Not Bright, Not Clear, Not Tired	0	0

More precise information about the primary source of the eye tiredness effect is acquired based on the data in the correlation table of room light lux with a combination of visual features (Table 4), which shows that dim light contributes five times to appear in seven combinations of data. Only two out of seven occasions for the data combination did object visibility drop. However, it has been established that eye fatigue occurs when the lux level is between (56,56 ± 0,12) lux and (67,73 ± 0,12) lux is caused by a combination of reduced brightness and visibility. When the light is bright, namely at the highest lux, the condition of the eyes is not exhausted. Consequently, it is discovered that lighting significantly aggravates weary eyes. The light intensity value is at the (69,93 ± 0,66) lux threshold for eye comfort; if the lux value lowers significantly, it will have the effect of making your eyes feel fatigued. Therefore, it is hoped that the light intensity value in the classroom will be over (69,93 ± 0,66) lux and distributed uniformly at all of the classroom's coordinate positions in the future.

According to the theory, poor lighting in a learning environment can cause the following effects: eye fatigue with decreased power and work efficiency, mental fatigue, complaints of soreness and headaches around the eyes, damage to the visual apparatus, and work accidents. The research results support this theory. Lighting contributes to a secure and comfortable learning environment and has a bearing on academic output. Additionally, poor illumination will cause workers' eyes to hurt, make them tired, and give them headaches. Better illumination can boost efficiency, boost output, and lessen challenges and visual stress during learning activities.

According to the standards established by the Illuminating Engineering Society of North America (IESNA) and the European Standards (CEN), it is advised to increase the number and power of lamps so that the light intensity ranges between 300 and 500 lux (Safranek et al., 2020). White boards and LED lighting in the classroom have an impact on the illumination quality as well (Liu et al., 2023; Magero et al., 2023). It is advised that classrooms at Universitas Muhammadiyah Lamongan increase the number of lights so that the lighting intensity ranges from roughly 300 to 500 lux. And add some control system with additional sensors that control the lightin g in the classroom (Kim et al., 2020).

CONCLUSION (5%)

According to the study's findings, Muhammadiyah University Lamongan's class A302 experiences eye tiredness as a result of the low light intensity levels in the space, which range from (56,16 ± 0,32) lux and (69,93 ± 0,92) lux. If the light intensity value is greater than 69 lux and is evenly distributed among all coordinate locations, which are the points where students are seated during lecture activities in class A302, the weary eye effect will vanish. According to this study, there is a connection between eye difficulties, the existence of curtains, the number of windows, the presence of a blackboard, the orientation of the classroom, and the postures in which pupils are seated and the consequences of eye strain. It is advised that classrooms at Universitas Muhammadiyah Lamongan increase the number of lights so that the lighting intensity ranges from roughly 300 to 500 lux. This will ensure that the interior lighting is of high quality.

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