Illuminance Affecting Factors Analysis for Classroom Environments

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Abstract. The reasonable placement of lamps in the classroom will play a vital role in the classroom lighting environment of the classroom, in which the classroom lights and blackboard lights, as the two most important parts of the classroom lighting environment, their importance is self-evident. The illumination level in the classroom can be improved by adjusting the position of the blackboard lights and the classroom lights. At the same time, the influence of the lamps on the illumination level in the classroom is analyzed, and the best parameters are selected by changing the installation position and rotation Angle of the lamps, so as to put forward optimization suggestions for improving the illumination level in the classroom.

Keywords: Classroom lighting environment · Analog simulation

1 Introduction

As one of the important elements of human living environment, light provides a bright and comfortable living environment for human living life. Normal people get more than 87% of the external information through vision [1]. A good indoor lighting environment can effectively reduce eye fatigue, ensure the health of visual organs, and improve learning or labor efficiency. However, according to a number of scholars and institutions carrying out a lot of tests on the lighting environment of the local classroom, it is found that the illumination level and glare of the desktop and blackboard surface do not meet the existing relevant standards, among which the factors affecting students' vision include lighting environment deviation, learning pressure, unsanitary use of eyes, etc [2–5]. At the same time, it is also found that it can improve the visual comfort of students when illumination and reduce the glare of lamps, and improve their learning ability [6].

The placement of lamps in the classroom plays a very important role in the level of illumination in the classroom. The reasonable layout of lamps can improve the uniformity of illumination in the classroom. At the same time, there should not be too strong contrast between light and shade in the classroom. When the light and shade in the field of vision change sharply, the human eye can't adapt well, which will cause the decline in the city. If the eyes need to frequently adapt to a variety of different brightness, it is easy to produce visual fatigue [7].

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2 Classroom Environment Design

2.1 Build a Classroom Model

The DIALux EVO software is used to establish a classroom space of 9.00 m long, 7.40 m wide and 3.50 m high. The blackboard in the classroom is 4.00 m long, 1.20 m wide, 0.20 m thick, and the bottom of the blackboard is 1.00 m from the ground. According to the relevant standards of the surface reflectivity in the classroom, the ceiling reflectivity is set at 0.70, the front wall reflectivity is set at 0.50, the side wall and rear wall reflectivity is set at 0.70, the ground reflectivity is set at 0.20, the blackboard surface reflectivity is 0.20 [10]. Items in the classroom include projector, multimedia curtain, lockers, curtains and so on. There are 30 desks in the classroom, available for 30 students. Figure 1 shows the simulation diagram of the classroom.

Fig. 1. Classroom simulation diagram.

2.2 Lamps Selection

The blackboard lamps and the classroom lamps in the classroom are installed by the boom rod. Three sets of blackboard lamps and eight sets of classroom lamps are selected. Figure 2 shows the arrangement of the lamps.

Blackboard lamps select LED lamps with grille and reflector, whose power is 36W, color temperature is 5000K, Luminous flux is 2880 lm, and color rendering index is 90. Classroom lamps select LED lamps with transparent cover, whose power is 36W, color temperature is 5000K, Luminous flux is 3000lm, and color rendering index is 90. The detailed parameters of the lamps are shown in Table 1.

The classroom area is 66.60 m^2, with 11 sets of lighting fixtures, including 3 sets of blackboard lamps and 8 sets of classroom lamps. The total power is 396 W, and the power density is 5.95 W/m^2. It meets the requirements that the classroom block lighting power density shall not be higher than 9 W/m^2 [10].

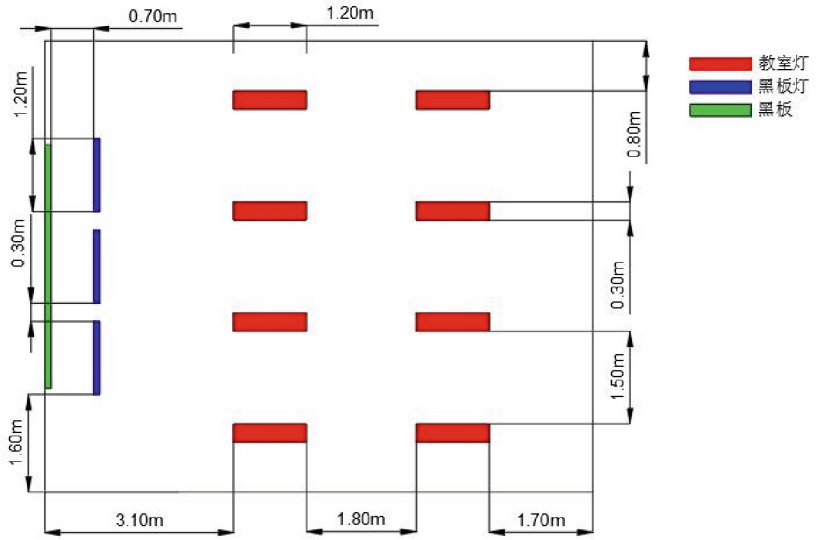
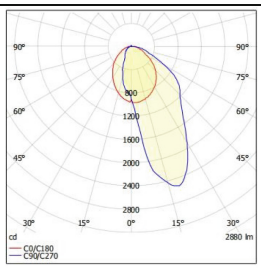
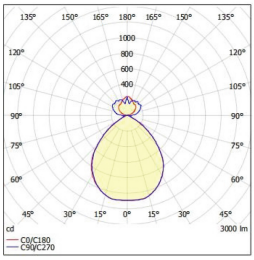


Fig. 2. Lamps layout.

Table 1. Lamps parameters

Types of lamps	Light source type	Parameter	Quantity	Distribution curve flux
Blackboard lights	LED	Power：36W Color temperature：5000K Luminous flux：2880lm Color rendering index：90 Levels of protection：IP20	3	
Classroom lights	LED	Power：36W Color temperature：5000K Luminous flux：3000lm Color rendering index：90 Levels of protection：IP20	8	

2.3 Judgment Criteria

The desktop illumination will be judged by the level illumination of the 0.75 m high desktop area. The blackboard illumination will be judged by the vertical illumination of the blackboard surface area. The UGR measurement point is at the center of the rear wall 1.10 m away from the rear wall [8].

The final simulation results are evaluated based on the relevant criteria, judged as follows:

(1) The maintenance average illumination of the class desktop should not be less than 300 lx, and the illumination uniformity should not be less than 0.70.
(2) The maintenance average illumination of the blackboard surface should not be less than 500 lx, and the illumination uniformity should not be less than 0.80.
(3) The uniform glare value at the position of the student observation point should not be higher than 16.0 [10].

3 Factors Affecting the Illuminance of Classroom Environment

3.1 Effect of Classroom Lamps Installation Height on Illumination

The height of the simulation surface of the desktop illumination is 0.75 m, GB 7793-2010 stipulates that the vertical distance between the classroom lamps and the desktop should not be less than 1.7 m [11]. In this simulated data collection, the installation height of classroom lamps is 2.6 m–3.3 m, which tries to comply with the actual use. In this simulation, the desktop illumination and illumination uniformity of the classroom lamps are collected at the installation height of every 0.10 m. The changes of the illumination and illumination uniformity in the simulation are shown in Fig. 3.

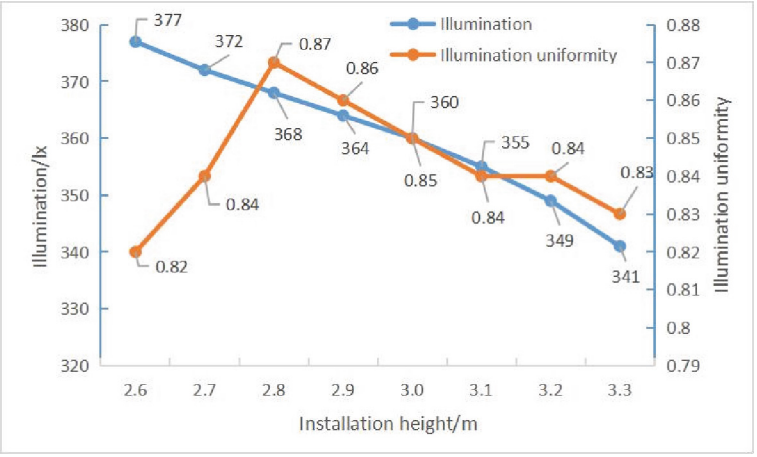


Fig. 3. Effect of installation height on illumination.

As can be seen from Fig. 3, when the installation height of the classroom lamps increase, the average illumination of the desktop is gradually reduced from 377 lx to 341

lx. The highest illumination uniformity is achieved at the installation height of 2.80 m. At this time, the desktop maintains the average illumination is 368 lx, and the illumination uniformity is 0.87. Meet the requirement of maintaining average illumination not less than 300 lx, and the uniformity of illumination also meets the requirement of no less than 0.7.

3.2 Influence of Classroom Lamps Distribution on Illuminance

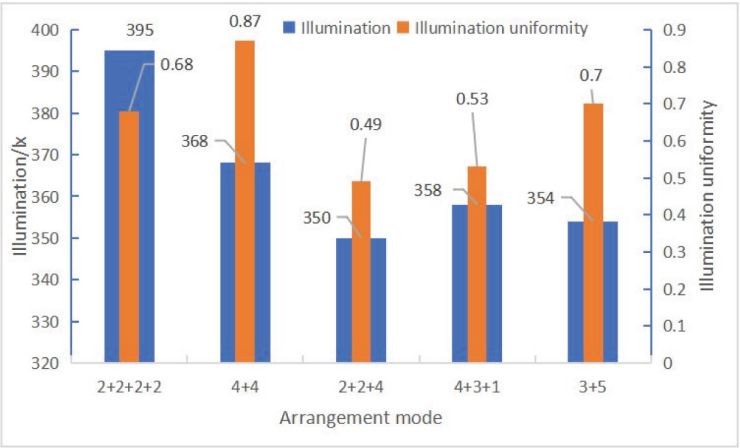


Fig. 4. Influence of classroom lamp distribution on illuminance.

As shown in Fig. 4, five different classroom lamps distributions are selected. Different lamps create different lighting environment. Among the five permutations, although the average desktop illumination maintenance meets the requirement of no less than 300 lx, only two groups of desktop illumination uniformity meet the requirement of no less than 0.7. That is, the second group on the left and the first set on the right in the figure. The data of the second group on the left is much better than that of the first group on the right. Considering that the arrangement of the lamps in the classroom needs to be neat, the arrangement of the second group on the left is selected.

3.3 The Influence of the Blackboard Lamps Spacing on the Illuminance

As shown in Fig. 5, the influence of blackboard lamps on the level of blackboard illumination when the distance between blackboard lamps changes. As you can see from the figure, when the spacing is 0.30 m. When the spacing is 0.70 m, the illumination and illumination uniformity are the lowest. Therefore, the data is optimal when the blackboard lamp spacing is 0.30 m.

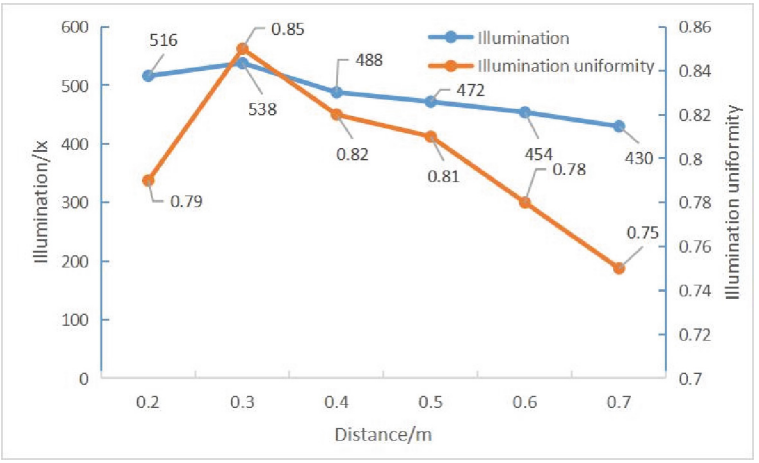


Fig. 5. The influence of the blackboard lamps spacing on the illuminance.

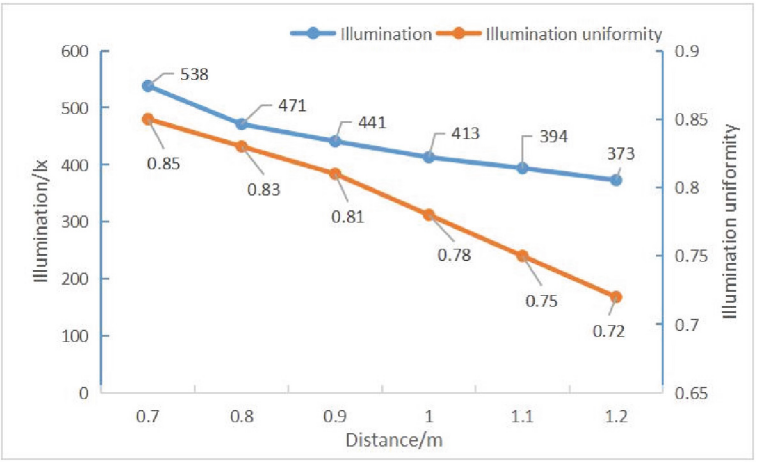


Fig. 6. Effect of the horizontal distance between the blackboard lamps and the blackboard on the illuminance.

3.4 Effect of the Horizontal Distance Between the Blackboard Lamps and the Blackboard on the Illuminance

As shown in Fig. 6, when the horizontal distance between the blackboard lamps and the blackboard surface is between 0.70 m and 1.20 m, the illuminance and illumination uniformity of the blackboard surface also decrease. Only when the distance is 0.70 m, the average illumination and illumination uniformity of the blackboard surface meet the requirements of 2.3 above. Therefore, the horizontal distance between the blackboard lamps and the blackboard surface will be selected as 0.70 m.

3.5 The Influence of Vertical Distance Between Blackboard Lamps and Upper Edge on Illumination

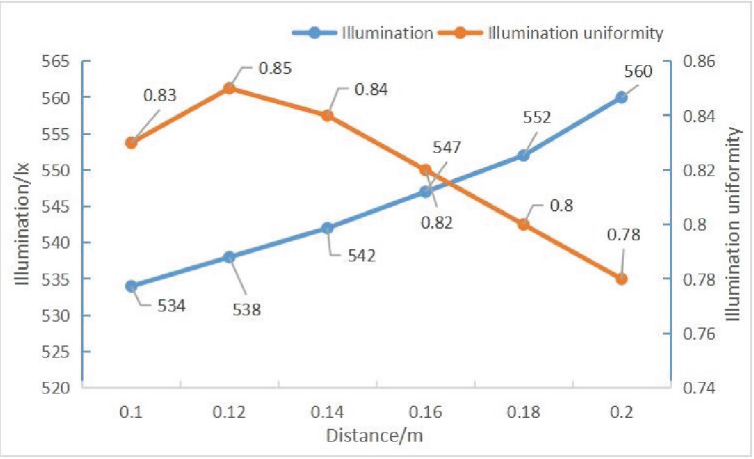


Fig. 7. The influence of vertical distance between blackboard lamps and upper edge on illumination.

As shown in Fig. 7, the vertical distance between the blackboard lamps and the upper edge affects the blackboard. It can be seen that as the distance increases from 0.10 m to 0.20 m, the illumination keeps increasing. The minimum value of 534 lx meets the requirement of maintaining the average illumination in 2.3. When the distance is 0.12 m, the uniformity of illuminance is 0.85, and the requirement of uniformity of illuminance is not less than 0.80 in 2.3 above. Since the illumination meets the above requirements, the distance between the lamp with the highest illumination uniformity and the upper edge of the blackboard, that is, 0.12 m. At this time, the average illumination of the blackboard surface is 538 lx and the illumination uniformity is 0.85.

3.6 Effect of Blackboard Lamps Rotation Angle on Illuminance

As shown in Fig. 8, the illuminance and illumination uniformity of the blackboard surface are analyzed for different rotation angles of the blackboard lamp to determine its influence on the illuminance level of the blackboard surface. With the increasing rotation angle, the illumination increases first and then decreases, with a minimum of only 356 lx and a maximum of 972 lx. In terms of illumination uniformity, with the increase of rotation angle, illumination uniformity decreases and then increases, with the lowest only 0.33 and the highest 0.85. When the rotation Angle is 0° and 15° respectively, the average illumination and illumination uniformity of the blackboard surface meet the requirements of 2.3 above. However, when the rotation angle is 0, the illumination uniformity is higher. Considering that the illumination gap between the blackboard surface and the desktop is too large, resulting in students' eyes switching between light and shade repeatedly, resulting in visual fatigue [7], so the rotation angle is 0°.

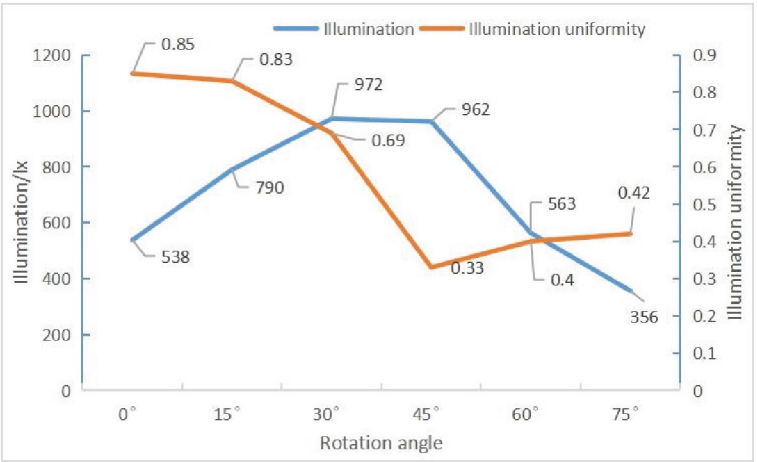


Fig. 8. Effect of blackboard lamps rotation angle on illuminance.

4 Simulation Optimization Results

As can be seen from the previous chapter, the installation height of classroom lamps is 2.8 m, and the arrangement mode is evenly distributed in two rows, with 4 lamps in each row. The distance between the blackboard lamps is 0.30 m, the horizontal distance between the blackboard lamp and the blackboard surface is 0.70 m, the vertical distance between the blackboard lamp and the upper edge of the blackboard is 0.12 m, and the rotation angle is 0°.

According to the above conclusions, the optimization simulation of the classroom lighting environment is carried out. In the simulation process, the central point distribution method is applied to collect the data of the illuminance and illuminance uniformity of the blackboard and desktop. The data are shown in Table 2.

Table 2. Simulation result

Parameter name	Technology	Optimize the results
Maintain average illumination on the desktop	≥300 (lx)	368.0
Table illumination uniformity	≥0.7	0.87
Blackboard maintains average illumination	≥500 (lx)	538.0
Blackboard illumination uniformity	≥0.8	0.85
UGR	≤16	13.1
Lighting power density	≤9(W/m^2)	5.95

According to the above optimization results, all parameters meet the requirements of 2.3 above. At the same time, the isoilluminance diagrams of class desktop and blackboard surface are obtained, as shown in Figs. 9 and 10.

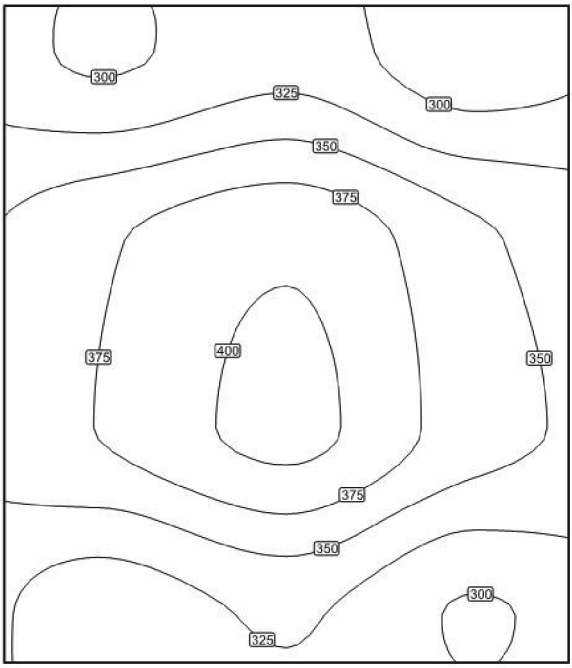


Fig. 9. Isoilluminance diagram of desktop.

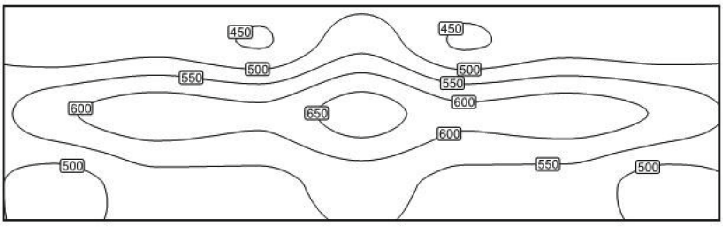


Fig. 10. Isoilluminance diagram of blackboard surface.

5 Conclusion

Through the simulation of Dialux Evo software, this paper analyzes in detail the installation height and distribution of classroom lights, as well as the influence of the position and rotation angle of blackboard lights on the illumination of classroom environment.

The results show that among the environmental illumination factors in the classroom. The installation height and distribution of the classroom lights, the position and rotation Angle of the blackboard lights relative to the blackboard all have a certain impact on the environmental illuminance in the classroom. In the optimization of classroom environmental illumination, it is necessary to optimize the classroom simulation, so as to achieve a better classroom environmental illumination level.

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