

Investigation and analysis on the illumination of the university classroom

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Abstract. Appropriate classroom lighting environment in universities should be able to meet the needs of the students physical and mental, and it has the practical significance to improve the student' vision, physical and mental health and learning efficiency. The paper uses the subjective and objective research method to investigate and analyse the present illumination situation of the university classroom based on the national standard of the <Architectural Lighting Design Standards>: GB50034-2013. According to the research results, we put forward the improvement scheme of the automatic control mode of the four kinds of classroom illumination and add the blackboard lamps, and then use the DIALux software to simulate the improvement effect, and obtain the energy saving benefit analysis table, so we can provides the program and data support for the classroom lighting.

The introduction

According to the research center of China healthy development in Peking University, Adolescent myopia prevalence has been ranked the first in the world[1].The < 2010 national physique monitoring result bulletin of Beijing> shows:the eyesight unqualified rate of junior high school students reaches 71%, the high school students is 81%,the college students is as high as 90%, More important is that the level continues to grow [2]. Therefore, the influence of the classroom lighting conditions on the students' vision becomes increasingly visible.

The classroom is the main place for students to study in school, and the classroom lighting constitute the artificial light environment for students to study . Human visual activity is closely related with the activities of the whole organism and higher nervous system. When the lighting environment is not suitable for vision of people, the visual efficiency declined significantly. This will not only affect visual fatigue, myopia, central nervous system ,but also the body activity will be subdued.Once appear this kind of situation,The students will feel exhausted of body and mind and the attention is susceptible to interference.So,it will reduce the learning efficiency. Good classroom lighting design should be able to meet the needs of the students physical and mental and suitable for students for a long period to study and work. It not only has the appropriate illuminance value, but also the all the parameters should meet the requirements of lighting quality.This will provide better lighting environment[3]. Therefore, the suitable university classroom lighting environment to improve the students' vision, physical and mental health and learning efficiency has important practical significance [4].

School building lighting design standard [5]

In order to guarantee on the work needed for visual brightness and brightness contrast [6], the national ministry of construction term definition and standard of architectural lighting design indexes.

Illumination.

The value of the luminous flux per unit area, name as : $E = d\Phi/dA$. The amount of the symbol for the E, the unit for lux (lx), $1 \text{ lx} = 1 \text{ lm/m}^2$.

Intensity of illumination evenness.

On the surface of the minimum intensity of illumination and the ratio of the average illuminance, symbols for U_0 .

Chamber shape index.

The geometry of the room Numbers. Its calculation formula is:

$$RI = 2 s/h * l$$

Room type, RI: shape index; S: room area; L: room level circumference; H: calculated height of lamps and lanterns.

The lighting power density.

Lighting installation power per unit area (including the light source, ballast or transformer), the unit of watts per square meter (W/m²).

$$\text{The LDP} = E_{av}/\eta_s * U * K$$

Type in the E_{av}: maintain the average illuminance; Eta s: the room light source (including ballast) average photosynthetic efficiency, lm/W. U: utilization coefficient; K: maintenance coefficient.

Tab.1 Standard for education building illumination

lighting target	numerical value
The blackboard illumination (lx)	500
Desktop illumination evenness	0.60
The blackboard lighting uniformity	0.70
lighting power density (W/m ²)	9.0
room index	1.5
color rendering (Ra)	80
light source	Small diameter straight tube fluorescent lamp
color temperature (K)	≤4000
mounting height of luminaire (m)	3.00

The classroom lighting measurement

To understand and analyze the present situation of university classroom lighting based on college classroom lighting as the research object, from the present situation of lighting two aspects of objective measurements and subjective evaluation, investigation analysis about the present situation of classroom lighting [4], and on the basis of new standards, to make scientific and rational survey evaluation and Suggestions for improvement.

Subjective survey.

1) Respondents

For all the students in university, a random sample of 400 as the respondents, through the way of questionnaire to fill out the classroom lighting, complete the subjective satisfaction survey.

2) Survey content

The blackboard and surface clear, different types of classroom lighting overall satisfaction, satisfaction the blackboard lighting, lamps and lanterns installation direction and height rationality, satisfaction survey rationality automatic lighting control mode, etc.

3) Evaluation method

Through regression analysis [7] anomalies observed value analysis of survey data, and the direct comparison method analysis of respondents to the classroom lighting indicators of satisfaction.

4) Data processing and analysis

a) Students surveyed on the classroom lighting satisfaction

Through random surveys, to enter the classroom lighting satisfaction survey EXCEL spreadsheet, as shown in table 2.

Tab.2 The satisfactory table of classroom illumination

	Working surface brightness	Lamps and lanterns installation direction	mounting height of luminaire	auto-control mode
I	29.55	15.91	20.45	18.18
II	43.18	45.45	38.64	22.73
III	18.18	18.18	20.45	20.45
IV	9.09	15.91	11.36	31.82
V	0	4.54	9.10	6.82

Note: I: satisfaction degree is high, II: III: higher satisfaction degree and satisfaction degree, IV: satisfaction degree is low, V: satisfaction is low. Numerical units: %.

The data import minitab16 software, using regression analysis survey data authenticity and rationality, and regression model equation are obtained. The results of the analysis as shown in table 3.

Satisfaction value = $-2.02165 + 0.156879 \times \text{Working surface brightness} - 0.136964 \times \text{Lamps and lanterns installation direction} + 0.0394721 \times \text{The installation height of lamps and lanterns} + 0.0416817 \times \text{Automatic control mode}$

Tab.3 Analysis of variance of regression equation

variance	Degree of freedom	Seq SS	Adj SS	Adj MS
regression model	4	10.00	10.00	2.50
Working surface brightness	1	7.55	1.27	1.27
Lamps and lanterns installation direction	1	2.18	0.32	0.32
mounting height of luminaire	1	0.16	0.01	0.01
auto-control mode	1	0.11	0.11	0.11

Can be concluded from table 3, survey data values, there is no abnormal observations, namely real effective survey data, by the survey data concludes truly reflect the surveyed students' satisfaction about the present situation of classroom lighting.

Can be seen from table 2, the surveyed students satisfied with the teaching classroom lighting face brightness degree is high, the installation height of lamps and lanterns and the direction of the satisfaction, satisfaction with the minimum of automatic control mode. Need to declare, the school classroom existing automatic control mode for the keying infrared type lamps and lanterns, when meet the signal lamps and lanterns is normal work. Thus, the school students' consciousness of energy conservation and environmental protection is increasing, hope the classroom lighting more wisdom, greening and humanization.

Survey shows that students satisfied about the present situation of the school classroom lighting, and hope that the classroom light automatic control method is more intelligent and humanization. In addition, the blackboard glare phenomenon is serious, need to be further solved, Yao the [8], etc. Through the computer simulate the blackboard without glare lighting design.

Objective to measure.

1) Measuring equipment and instruments

Zhejiang university three color radiation spectrum analyzer SL - 300; Konica minolta luxmeter LS - 100; Laser range finder; Canon EOSM.

2) Measuring points

Direction of the classroom and the board size, installation of lamps and lanterns, quantity, type, color temperature, type, power, electrical parameters, such as the distance to the ground, ceiling lamps and lanterns, the classroom walls, ceiling, and the color and the material of the floor, the classroom and blackboard illumination.

3) Measuring method

The classroom and blackboard size measurement: according to GB/T17986.1-2000 [9], the

trilateral measurement method is adopted.

Illumination measurement: according to GB/T 5700-5700 [10], the center location method is adopted.

Among them, in front of the classroom as the platform, is not a normal students face, so the corresponding area of illuminance will not be measured. Classroom illumination center location diagram is shown in figure 1.

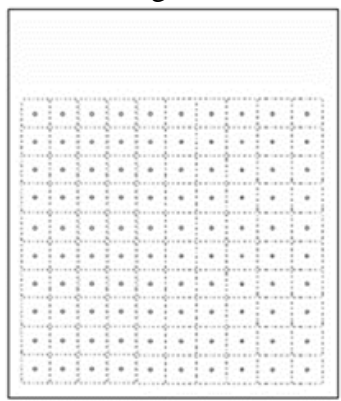


Fig.1 Center method of classroom

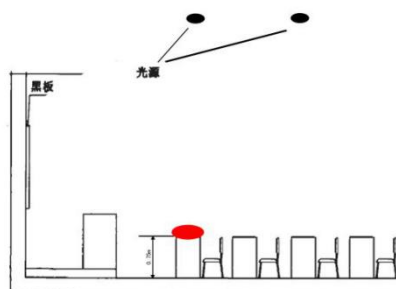


Fig.2 Center method of working-face

In view of student learning, working with a certain height, according to GB/T 3976-3976 [11], school classroom desks height is 0.75 m. Students face illumination measurement diagram as shown in figure 2, the red areas for the working intensity of illumination measured height.

The blackboard illumination measurement center location diagram is shown in figure 3.

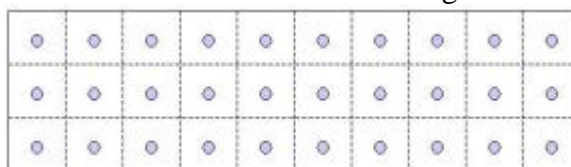


Fig.3 Center method of blackboard

4) Data processing and analysis

a) The classroom and blackboard size measurement

Select A classroom as A representative of the small classroom, classroom size is: 8.18 m * 8.58 m * 8.58 m; Select the classroom B as a representative of the medium of the classroom, the classroom size is: 12.70 m * 9.20 m * 9.20 m; District class C as a representative of the big classroom, classroom size is: 13.40 m * 13.40 m * 13.40 m. Detailed dimension measurement data as shown in table 5.

By the calculation, different types of classroom chamber shape index respectively: the classroom A RI = 1.86, the classroom B RI = 2.98, the classroom C RI = 2.37 . Because of the actual chamber shape index and standard values, lighting power density threshold for correction, chamber shape index and revised as shown in table 4.

Tab.4 room index and LDP amendment value

Classroom Name	room index	Revised lighting power density
Classroom A	2.98	8.28
Classroom B	1.86	9.00
Classroom C	2.37	8.28

b) The classroom and blackboard illumination measurement

According to the classroom and the actual size of the blackboard, the center location method is adopted, using the LS - 100 luxmeter survey each classroom and blackboard illuminance value, and the data entry EXCEL spreadsheet. Classroom and blackboard is calculated using DIALux software and average intensity of illumination and the intensity of illumination evenness. The calculation results as shown in table 6.

Tab.5 The size measurement of classroom and blackboard

	Classroom A	Classroom B	Classroom C
Length of the classroom/m	13.40	8.18	12.70
Width of the classroom/m	13.40	8.58	9.20
Length of the blackboard/m	6.00	4.00	6.00
The board width/m	1.20	1.20	1.20
Number of lamps and lanterns/a	40	24	40
Color Temperature/K	4147	4160	4381
Types of lamps and lanterns	1.2 mLED - T8 torch		
The lamp high from the ground/m		3.00	
The lamp from the ceiling height/m		1.20	
Lamp power/W		18	
color rendering		81	
Lamps and lanterns installation direction	Bilateral symmetry, coating aluminum reflector, aluminum grille white paint		
Metope material and color	White lime on metope, white ceramic tile		
Ceiling material and color	White plaster ceiling		
The floor material and color	Gray terrazzo		

Tab.6 Average illumination and uniformity of illumination of classroom and blackboard

Classroom	The average intensity of illumination/lx	The classroom illumination evenness	The blackboard average illuminance/lx	The blackboard intensity of illumination evenness
Classroom A	348.25	0.85	166.90	0.84
Classroom B	364.18	0.74	185.63	0.92
Classroom C	338.37	0.78	168.73	0.85

Tab.7 Standard evaluation of classroom illumination

lighting target	Measurement			Standard numerical
	Classroom A	Classroom B	Classroom C	
Desktop illumination (lx)	348.25	364.18	338.37	300
The blackboard illumination (lx)	166.90	185.63	168.73	500
Desktop illumination evenness	0.85	0.74	0.78	0.60
The blackboard lighting uniformity	0.84	0.92	0.85	0.70
lighting power density (W/m ²)	4.01	6.16	6.16	See table 4
room index	2.98	1.86	2.37	1.5
color rendering (Ra)	81	81	81	≥80
light source	1.2 mLED - T8 torch	1.2 mLED - T8 torch	1.2 mLED - T8 torch	Small diameter straight tube fluorescent lamp
color temperature (K)	4147	4160	4381	≤4000
mounting height of luminaire (m)	3.00	3.00	3.00	3.00

5) Outcome assessment

Through the school classroom lighting is subjective evaluation and objective data of measurement, high student satisfaction about the present situation of the school classroom lighting, automatic control mode of classroom and blackboard glare phenomena, remains to be further improved. Compared to the actual measurement results compared with the national standard, the results as shown in table 7, the results showed that the classroom lighting illumination in the classroom, intensity of illumination uniformity, lighting power density, the light source color rendering, color temperature, lamps and lanterns installation height and blackboard illumination uniformity basically met the national standard, but serious deficiencies in the blackboard illumination.

Recommendations for improvement

For survey found insufficient blackboard intensity of illumination and glare and other problems, on the premise of guarantee does not produce glare, add the blackboard lamp, according to Liulin [12] on no glare effect of classroom lighting design optimization scheme and the building lighting design standard "regulation, the observer sitting eye height is 1.2 m, standing eye height is 1.5 m, and will not affect the normal teaching teachers, can be calculated, the blackboard lamp should be installed in the teachers' level of 45° elevation above the line of sight, height $H > 2.45$ m, is apart from the blackboard $L < 0.53$ m. At the same time shows the CAD drawing of the classroom, as shown in figure 4.

To survey the lamps and lanterns of automatic control unreasonable problem, this paper recommend the use of multiple model control automatic lighting system [13], on the premise of energy conservation and environmental protection, in order to meet the needs of students in the classroom lighting. The classroom lighting can have the following four patterns: self-study mode, daytime mode, teaching mode, presentation mode.

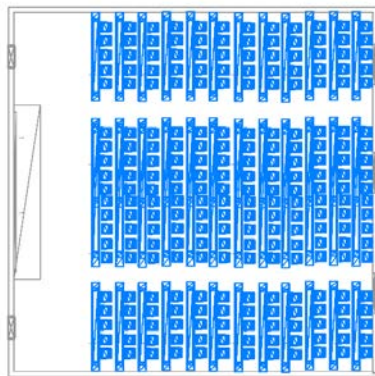


Fig.4 Classroom size

Self-study mode, when the evening self-study students, the classroom illumination constant lighting requirements, meet the requirement of "building lighting design standard", the science of classroom lighting, as shown in figure 5

Daytime mode, because of the uncertainty of the weather, the classroom illumination cannot be constant, and near the corridor side low intensity of illumination, in order to guarantee the classroom lighting to meet the new standards under the premise of reasonable fill light, to meet the needs of the students normal learning of illumination, as shown in figure 6

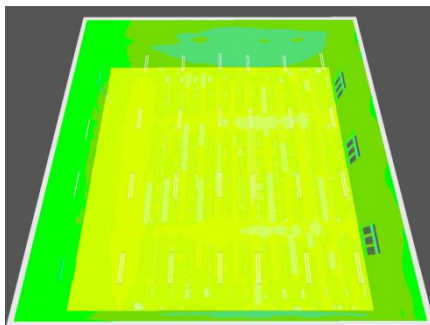


Fig.5 Self-study mode

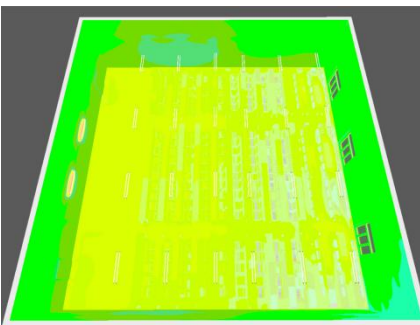


Fig.6 Day mode

Teaching mode, when teachers blackboard writing or tell the content, in the guarantee the blackboard does not produce glare with blackboard writing content under the premise of clear, open the blackboard lamp and the classroom lighting lamps and lanterns, and the real-time fill light as shown in figure 7;

Speech patterns, in the process of play and the speech, on the premise of guarantee the PPT content definition, the classroom in a reasonable manner to fill light, such as closing the blackboard lights, lamps and lanterns of open distance from the board, as shown in figure 8.

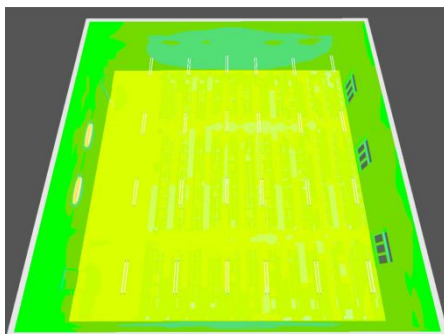


Fig.7 Teaching mode

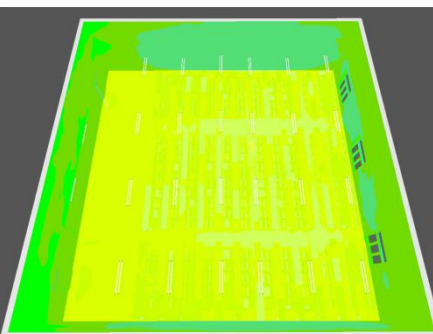


Fig.8 Speech mode

To verify the improved classroom lighting effect, this article put DIALux software for simulating mode of classroom lighting lamps and lanterns of fully open, as shown in figure 9, in order to contrast before and after improvement of lighting effect. In addition to verify the classroom before and after modification evenness increased, at the same time using DIALux simulate the pseudo color image, respectively, as shown in figure 10 and figure 11.

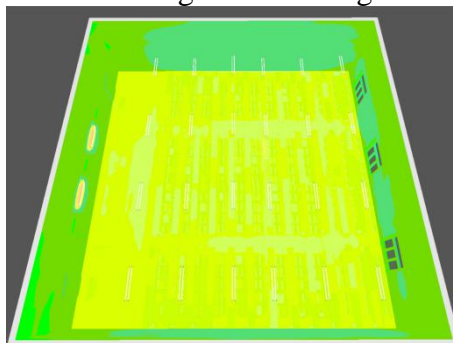


Fig.9 Fully open mode

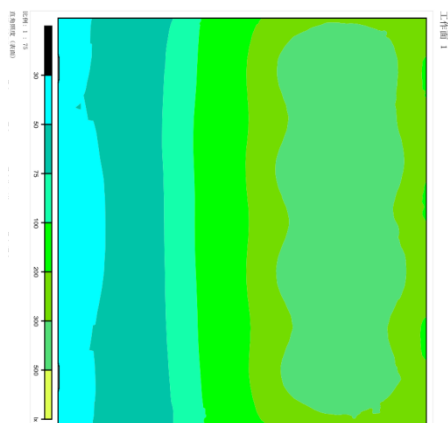


Fig.10 the actual state Pseudo Color

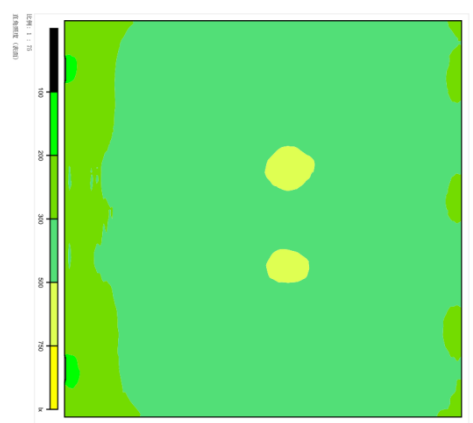


Fig.11 the imitate state Pseudo Color

Conclusion

The classroom as the main learning of students during the period of school location, the lighting environment myopia and the influence of physical and mental health is very important for students. To better build the classroom lighting environment, should with "building lighting design standard" and other national standards as the basis, aiming at health lighting [14], reasonable build appropriate classroom lighting light environment, to improve the students' vision, physical and mental health and learning efficiency is of great significance.

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