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ANALYSIS OF LIGHT CONDITIONS OF TWO CLASSROOMS OF CAA BLOCK AT UNIVERSIDADE FEDERAL DE CAMPINA GRANDE

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Abstract. *Proper lighting of an environment is a key factor for the performance of activities to be carried out. On the other hand, the lack of it can cause serious problems that directly or indirectly affect the health of people using those sites: from lack of concentration and visual fatigue to accidents caused by glare. Due to the great influence caused by the luminance of the sites in the performance of activities, felt the need to analyze the lighting conditions of the classrooms, 104 and 405 of the CAA block located at the Federal University of Campina Grande. Through a quantitative, qualitative exploratory study illuminance levels were analyzed in rooms with the lights on in order to check the illuminance level on both sites. Therefore, it was found that both rooms have analyzed the levels of luminance discontinuities.*

Keywords: *Classroom. Illuminance. ABNT ISO/CIE 8995-1.*

1. INTRODUCTION

The development of critical thinking, communication skills, professional training for the labor market are some of the developed functions within a Higher Education Institution (HEI). It develops an important role in society and serves as a mirror in the construction and development of people in personal aspect as well as professional.

HEIs are composed by several factors that together can achieve the objectives ascribed to them. Some of these factors are: teaching staff, quality of teaching, research projects, infrastructure (library, university restaurants, classrooms, etc.) and students. University students join to HEIs semiannually or annually to improve them knowledge in a specific area and ensure their professional qualification. Therefore, accessibility and comfort of these students and professors in those environments must be provide a well-being during their stay on site, that sometimes becomes their second home due to time spent during the week.

Therefore, these environments must necessarily be appropriate for students to work satisfactorily and teachers can offer a better quality of education. For this, some factors are fundamental in to achievement of these goals, for example the lighting in the rooms, the position of worker to perform their activities, noise, temperature, repetitions of movements, the dimensions of the workplace, colors, vibrations, etc.

Thus, due to the high number of buildings being built at the Federal University of Campina Grande (UFCG) felt the need to analyze the conditions that are running the classrooms projects and what conditions students are being submitted to acquire knowledge. It was determined as main objective the analyze of illuminance level in two classrooms - 104 and 405 – on the CAA block.

However, to be able to analyze the lighting of classrooms of detailed and reliable required to perform some preliminary steps such as, the way in which room has being lit (natural or artificial lighting), number and arrangement of fixtures in workplace, and the acceptable level for particular environment with regard to the illuminance of white environments.

The excessive number of fixtures during the day is one of the hypotheses that could be confirmed or not with the data analysis.

2. LITERATURE REVIEW

2.1 Classroom

It is known that the classrooms are one of the main environments in schools or universities because that is where students spend most of their time. Several activities are developed in this study environment and it needs several features to make the classes more dynamic and interesting.

In general, students' perceptions can be divided into three categories: perception of the psychosocial environment such as belongingness and connection with classmates; perception of the psychological environment such as motivation, self-efficacy and achievement; and perception of the physical environment such as classroom size, lighting and technology. (Yang and Mino, 2013)

Thus, in addition to the multimedia equipment, and teaching and methodology of each teacher, there are several other factors that directly or indirectly influence on student learning, they are: the layout of the classroom, the furniture used, technological equipment, levels of lighting, noise, ventilation and visibility.

Students and instructors suffer from interior problems of classrooms such as inadequate lighting, noise, glare, poor air quality, inappropriate temperature, uncomfortable seats and inflexible seating arrangement. (Rydeen, 2003, Obeidat, 2013)

For instance, the National Center for Education Statistics (U.S. Department of Education, 2000) asked schools to rank how satisfactory or unsatisfactory six different environmental conditions were: lighting, heating, ventilation, indoor air quality, acoustics and physical security of the building. The survey revealed that an average of 2.6 environmental conditions was reported unsatisfactory among the 43% of schools that reported at least one unsatisfactory condition. In addition, 8% of schools rated all 6 environmental conditions unsatisfactory (U.S. Department of Education, 2000 apud Marchand *et al.*, 2014)

The classroom is the most important area in a school. […] It is where students and teachers spend a large amount of their time and, hence, it is an environment that is assumed to promote a reasonable level of concentration in learning activities such as discussing, reading, drafting, drawing, writing, and practicing. (Obeidat, 2012)

Thus, it is observed that there are many factors in the classroom environment that directly or indirectly influence on student learning. Most of them are part of a science that offers greater comfort to operators, employees or users of these environments. This science is called ergonomics.

2.2 Ergonomics

Ergonomics is the only science that has date of birth. His appearance was given at the end of the 2nd (second) world war, but specifically on 12 July 1949. (Iida, 2005)

At that time, a joint work in different fields such as engineering, physiology and psychology, have as a consequence the study of ergonomics. It emerged to study the conditions that work is being submitted and determine minimum conditions for to run satisfactorily and safely activities, improving health worker's life. (Iida, 2005)

The term ergonomics has several definitions, differing from author to author. It is understood by ergonomics the following concept:

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. (Internarional Ergonomics Association, 2015)

"Another important aspect is ergonomics as Balbinotti (2003) is that it seeks not only to prevent workers in jobs stressful and/or dangerous, but seeks to put them in the best possible working conditions to avoid accidental injury or fatigue excessive and improve performance. (Vieira *et al.* 2012)"

According Iida (2005, p. 3), ergonomics seeks to reduce fatigue, stress, mistakes and accidents, providing security, satisfaction and health of workers, during their relation with this production system.

One of the factors that might cause fatigue, stress, errors or accidents in work environments is exactly the excess or lack of lighting environments.

2.3 Lighting

People live in environments where most of the time is partially illuminated by openings, but predominantly lit artificially. Lighting is an important factor for visual comfort, and impact on productivity and the final quality of a service or product.

There are several reports on productivity growth after improving lighting conditions. These increases are partially a direct effect (faster through visual access from work) and partly indirect (through the reduction of fatigue). (Kroemer, 2005, p.228).

According to Iida (2005) the main photometric units are light intensity, luminous flux, illuminance, luminance and reflectance. Grandjean (1998 apud Battistella, 2003) says that the decisive conditions are: light intensity in the workplace, distribution of brightness in the visual field, the luminance, intensity of lighting, contrast and the formation of shadows.

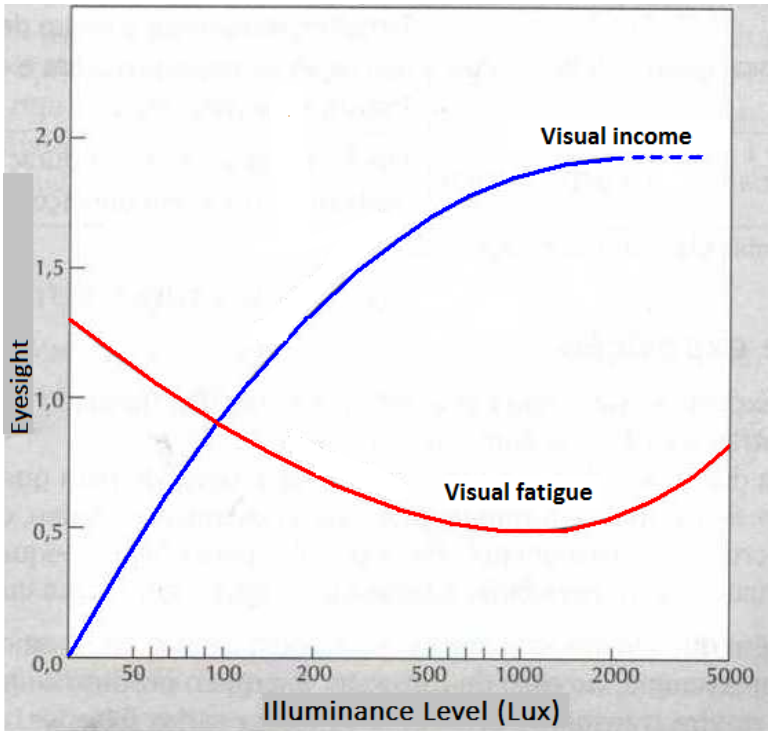

Figure 1. Changes in income and eyestrain due to the level of illuminance

According to Fig. 1, the visual performance increases with increasing illuminance level as the eyestrain is reduced in the range from 10 lux to 1000 lux. However, there comes a point at which the increase in the luminance level causes the start of visual fatigue in approximately 1000 lux as shown in the figure below. Thus, there is a value "great" to work in a workplace so as not to cause damage to vision.

For visual comfort it is necessary that the following conditions are observed: lighting intensity; local uniformity of luminous densities; temporal uniformity of light and glare-free arrangement of luminaires. (Anjos, Maribondo, 2009)

2.4 Light and color

In the past, the colors were used as a way to attract the hunting, causing an illusion. In the Christian religion it was explored as a way to distinguish their hierarchies.

The light is the way that is used to identify a place, person or object, otherwise it could not be identified by the human vision. The color, through the human eye, can be described by the amount of light achromatic (saturation), the reflection of light (luminosity) and the light-emitting by objects (brightness).

There are many factors that could influence the human education, such as: learning methods and techniques, methodology of teaching, the potential student (didactic and pedagogical factors), and environmental factors that according Iida (2005), are: lighting, color, temperature, noise and vibration.

The color exercises three actions: to impress the retina, to provoke a reaction and to build a particular language, communicating an idea, having symbol value and ability. The message can be transmitted without loss of signal, making it a powerful way of transmitting ideas. It is applied in some fields of human knowledge, such as psychology, art, medicine, ergonomics and safety. (Morton, 2000 cited in Battistella, 2003).

Light and color are important fact for the workplace, due to the time that the man is exposed, usually 8 hours of daily work. The correct application of light and color in the environments can influence, positively or negatively, as well cause discomfort, change the size, increase or decrease the concentration and contributes significantly in safety. Mahnke (1996 apud FONSECA, 2007), reports that it is not enough simply to "color" the workspaces it is necessary that the choice of colors is appropriate to the function of the space, the task and users characteristics who experience

this space. Already Kwallek (1996 apud in Battistella, 2003), says that if the color is properly applied, interacts positively, and if it is inadequate may cause eye strain, discomfort and stimulate stress, among other possible consequences.

The Regulatory Standard (NR) 26, safety signs, treats the relationship between colors and workplace security. The Brazilian Standard (NBR) 7195, colors to security, aims to set the colors that should be used for the prevention of accidents, used to identify and warn risks.

3. METHODOLOGY

After some complaints of students attending class at CAA block felt the necessity to analyze the conditions that these people were being subjected. Thus, among the various parameters that influences in this regard, such as the furniture, noise levels, ventilation, temperature, among others, picked up the illuminance level inside the classrooms focus to be analyzed.

Sequentially became a search in the literature in order to collect some information that would serve as a basis for completion of the work. Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), most published in the last five (5) years, as well as books and NRs were some of the research sources in order to acquire greater knowledge in the specific areas.

After this quest for knowledge, it was deemed necessary to determine some information such as the operating conditions and the amount of lamps, the arrangement of it, if there is natural lighting, if it is true determine this amount, location and size of the lighting , the colors of the walls, type of board that is used, among others. All these factors influence directly or indirectly in lighting quality in indoor environments.

Because of the time established to complete the survey, we tried to restrict the search to a sample rooms so it does not harm the result as a whole. Thus, restricted to research the two classrooms that are the rooms 104 and 405 of the CAA UFCG block.

Following, held photographs and footage of sites to be analyzed later. Concocted up a table to collect data. To collect illuminance levels used the equipment called light meter, Lutron brand, LX102 Light Meter model. The measurements were performed according to standard of the Associação Brasileira de Normas Técnicas (ABNT), ISO / CIE 8995-1.

After collecting the necessary data, analyzed it and made a comparison with the value set by the standard ISO / CIE 8995-1 for ordinary classrooms intended for adult education.

Finally, there was some recommendations to improve the quality of classrooms which students are undergoing in relation to internal lighting.

4. RESULTS AND CONCLUSION

4.1 Measurement analysis

After taking measurements started up several steps to analyze the data obtained. It is noteworthy that the day was sunny with few clouds in the days of measurements.

Room 104: The first measurements were made in room 104 which has a rectangular shape. The same has four (4) equally spaced rows of lamps. Each row (M) has eight (8) lamps. Each lamp has two lamps (N). Therefore, fluorescent lamps are used 64 40 watts (W) each. All lamps have signs of dirt (dust) accumulated on top of them. The room presents problems in the switch controlling the connection of the penultimate 4 lamps (lamps 8), so the measurements were performed with these lamps erased. Other three (3) lamps were not working for other reasons.

The Tab. 1 presents a description of the reporting environment.

Table 1. Description of environments analyzed

Room	Lenght (m)	Width (m)	Right foot (m)	Total area (m^2)	Color ceiling	Hall Color	Lamps color	Windows quantity
104	18,55	9,8	2,35	171,95	White	White e beige	White light	6
405	9,2	9,8	2,88	84,11	White	White e beige	White light	3

The average illuminance values obtained in three shifts (morning, noon and night) in room 104 of the CAA block of UFCG, are shown in Tab. 2.

Table 2. Average illuminance of the rooms with the lights on 104

Condition	1º Shift (morning)	2º Shift (noon)	3º Shift (night)
Lights on	531 lux	541 lux	534 lux

First of all, the level of average illuminance ideal was verified for classrooms with artificial lighting. Therefore, it was found that the "great" value for an environment is 500 lux and that it is just above the average established by the ISO / CIE 8995-1 for the environment with artificial lighting. However, the same rule establishes a tolerance of 10% more or less. So, the illuminance measurements are within the value set by the ISO / CIE 8995-1 in three shifts.

Room 405: The room has a rectangular shape. It has four (4) equally spaced rows of lamps. Two of the rows have four (4) light fixture and the other two each have five (5). Each light fixture has two lamps. Therefore they are used fluorescent lamps 40w 36 each. All lamps have signs of dirt (dust) accumulated on top of them. Unlike room 104, this is in perfect condition. All lamps are in perfect working order.

The average illuminance values obtained in the three shift (morning, noon and night) in room 104 of the CAA block of UFCG, are shown in Tab. 3.

Table 3. Illuminance average rooms with the lights on and off the room 405

Condition	1º Shift (morning)	2º Shift (noon)	3º Shift (night)
Lights on	734 lux	640 lux	690 lux

The procedure was performed in the same room 104. Thus, it was found that the illuminance level is far above the average value established by ISO / CIE 8995-1 for the environment with artificial lighting.

After analyzing the illuminance level of the rooms in question were found some irregularities, some of them already mentioned throughout of this article. So, the amount of lamps and fixtures necessary to provide a pleasant lighting to the occupants of that location was analyzed. The method chosen to carry out this evaluation was the method of lumens..

Therefore, since the only room that had problems with the illuminance level was room 405, the analysis by the method of lumens is only necessary in it.

4.2 Method Lumens

According Mamede Filho (2010) "the method of the lumens is based on the determination of the luminous flux required to achieve the average illuminance value on the work plan."

Initially, it was examined luminous flux "ideal" for that environment. For this used Eq. 1.

$$\Psi_t = \frac{S * E}{F_u * F_{dl}} \tag{1}$$

Where;

Ψ_t = total light output in lumens;
E = illuminance in Lux;
S = environmental field in m²;
F_u = coefficient of use;
F_{dl} = depreciation coefficient;

For the depreciation coefficient was found the value provided in Mamede Filho (2010, p. 51) for lamps with open and beveled rails.

To determine the utilization factor is required to determine the environment index (K) which is supplied by Eq. 2.

$$K = \frac{A * B}{H_{lp} * (A * B)} \tag{2}$$

Where;

K = environment index;
A = length of the environment, m;
B = width of the environment, m;
H_{lp} = height of the light source on the work plan, m;

After determining K obtaining reflectance of 0.7 or 70%, for light wall, with a reflectance of 50%, and dark floor to obtain reflectance of 10% for both rooms. (Mamede Filho, 2010, p. 52) Thus, the utilization factor for the room is given by 0.72.

The lamp used for lighting is the fluorescent type, 40 W and luminous flux equal to 3000 lm per lamp. This value was determined by Eq. 3. exposed below.

Thus, there was obtained the data shown in Tab. 4.

Table 4. Data considered in the calculation of the luminous flux

	Variables						Results
Room	E (lux)	F_u	F_{dl}	H_{lp} (m)	K	S (m²)	Ψ_t (lumens)
405	500	0,72	0,8	2,08	2,28	84,11	78.263,89

After that, it was determined the number of fixtures that the environment should have to provide a minimum level of illuminance of 500 lux. Therefore, we use Eq. 3 to determine the amount of luminaires since each lamp has two lamp of 40W each.

$$N_{lu} = \frac{\Psi_t}{N_{la} * \Psi_l} \quad (3)$$

Where;

Ψ_l = luminous flux emitted by a lamp in lumens;
N_{la} = bulbs numbers for fixtures;

The Table 5 shows the variables used and the data obtained.

Table 5. Calculation of the number of luminaires

	Variables			Results
Room	Ψ_t (lumens)	N_{la}	Ψ_l (lumens)	N_{lu}
405	78.263,89	2	3000	13,04

Therefore, the calculations show that the number of lamps in classrooms searches is much higher than necessary to provide adequate lighting. Rounding the values up of the room 405 it would require fourteen (14) light fixture, each one with two lamps of 40W.

4.3 Reduce of consumption (quilowatt – hour(Kwh) and monetary value)

Whereas it is ministered eight (8) hours per day from Monday to Friday, and during class all the lights are on, the monthly consumption time for these lamps are 160 (one hundred sixty) hours per month (considering the month with four weeks).

In the current situation are being used 36 (thirty six) lamps with the same characteristics in the room 405. Using the Company's Consumer Simulator Light and Power Santa Maria, the monthly power consumption and energy saving is shown in Tab. 6.

Table 6. Reduction of monthly energy consumption

Room	Current monthly consumption (KWh)	Proposed monthly consumption (KWh)	Monthly savings (KWh)	Value of the current consumption (R$)	Propose currently value (R$)	Monthly savings (R$)
405	230,4	179,2	50,8	63,26	49,20	14,06

5. CONCLUSION

Throughout this study aimed to analyze the illuminance level of the classrooms 104 and 405 of the CAA UFCG block. Before that, relevant information about the theme was researched to get firm conclusions about the analysis made.

The room 104 has a good level of illuminance and complies with the settled of current regulations.

However, it was found that the room 405 has one type of inconsistency with the established for excess lighting. This problem may be caused by a number of lamps required above.

Through the number of lamps studies' that would be needed to make good quality lighting shows the waste of energy in the classroom 405. With the calculations obtained a significant reduction in costs related to lighting, the savings was 22.23% compared to the amount currently paid. In monetary value means a savings of R$ 14.06 per month in just one room.

Some proposals were analyzed from the obtained results. They are:

• Reducing the number of lighted lamps, as they are turned on independently, row by row. This would make the environment more pleasant to human vision, reducing eyestrain.

• Regular maintenance of the light fixtures, since the dirt interfere significantly in the incidence of artificial light.

• Placement the rails fixtures to decrease the incidence of direct light in the workplace and human being, providing the diffusion of light.

• Replacement of colors or even the floor of the analyzed environments. The floor of the rooms is of dark color which does not favor a good light in the workplace.

• Replacement of work surfaces, because glossy surfaces difficult to read and facilitates the reflection of light becoming difficult in most of cases to improve learning of people.

During this research could observe the level of importance of the light factor in all locations, especially in the workplace, specifically in classrooms. Therefore, considering the results obtained in this article it is expected from those responsible for construction projects to give more attention with regard to the illumination design in order to provide a better working environment for the occupants of the environment.

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