Modernization of the Environmental Lighting System of a Manaus City Commercial Business

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Abstract

This research aimed to present a brightness control system through the Arduino prototype that will adjust the brightness in the workplace according to the Brazilian norms according to the activities performed and through the literature review point its advantages and benefits to the company. To this end, the following research methodologies were adopted: case study, literature review, quantitative and qualitative analysis. Where illuminance samples were collected in a work environment where they are outside the standard of NBR 8995-1, a fact that has been negatively influencing workers performance and company results, a high level of energy consumption was also detected energy. Thus, based on the literature review on the subject,

and the results obtained in the inspection of the illuminance of the work environment, it was possible to present a prototype on the Arduino platform that solved the problem of lighting in the work environment, regarding the quantitative results of the work. Research has proven that with the installation of the prototype in the workplace the energy reduction can vary from 7% to 20% in addition to the reduction of occupational disease costs, and the qualitative results show numerous benefits of adequate lighting in the workplace. minus three spheres: physical; cognitive and operational.

Keywords: Lighting. Workplace. Lighting control. Arduíno;

1. Introduction

A work environment is the result of a sum of factors, material and subjective, all very important. Environmental working conditions must be appropriate to the psychophysiological characteristics of the workers and the nature of the work to be performed. Thus, in workplaces where activities are performed that require constant intellectual solicitation, such as the office room, brightness is a prime factor in the performance of activities, which is standardized by NR-17 and NBR 8995-1.

In this context, the excess or lack of illumination and even illumination of environments designed outside the normative standards, directly affect negatively in the performance of the activities performed by the employees, favoring the emergence of some problems: physical, because it damages the visual senses of the persons and contributes to the development of physiological and mechanical deficiencies; cognitive, in relation to mental processes and interpersonal relationships in the workplace; and organizational, dealing with rules, communication and organizational structure; and the increased risk of accidents and other work-related illnesses. Scenario consisting of the following problem: How to modernize the lighting system in the workplace according to regulatory standards?

Therefore, this research aims to present a brightness control system through the Arduino prototype that will adjust the brightness in the workplace according to the Brazilian norms according to the activities performed and through the bibliographic review to point out its advantages and benefits. the company and the workers.

Interest in the topic arose from the need to adjust the lighting system of the administration room of a company in the commercial area of Manaus City, where it was made measurement and analysis of the brightness levels of the room and it was found that it is outside. regulatory standards on the subject, resulting in negative results for the company.

With the advancement of automation technology through the Arduino prototype, it is now possible to have automated lighting in the workplace, creating great comfort for workers, relating its functionalities with concepts of occupational safety, improving occupational health and safety. undoubtedly generated huge energy savings.

The idea of controlling brightness levels in the workplace works through computers, microcontrollers and lighting sensors, which gradually increase or decrease artificial lighting, so that the environment is always fit for the job to be. executed.

2 Materials and Methods

2.1 Area of study

The study was done in a commercial office located in Manaus city center (Figure 1). The room has an area of 25m2, where it is divided into eight workstations, each workstation has a computer and a chair, featuring fixed workstations. It is noteworthy that the room has no windows, completely depending on artificial lighting for development of daily work routines.

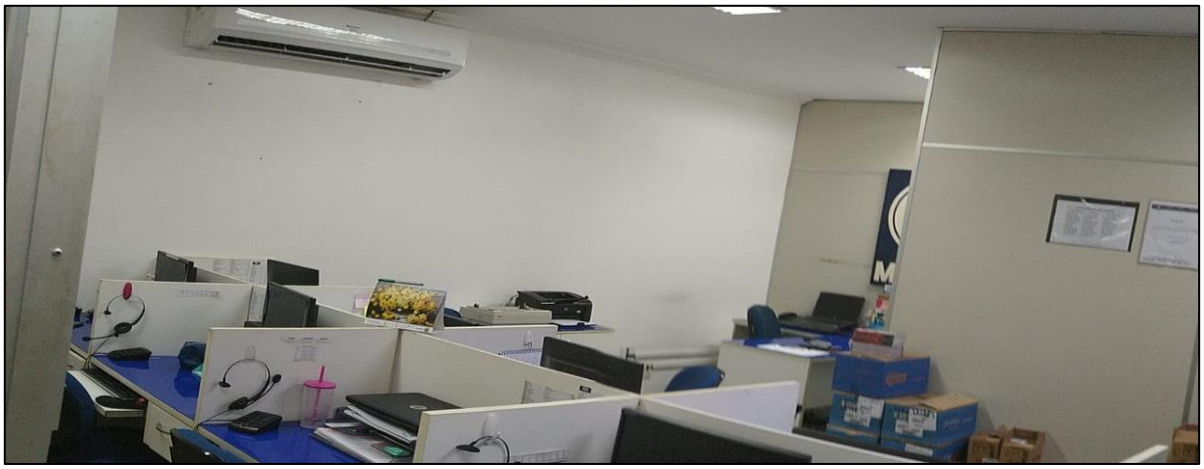


Figure 1. Place of study
Source: Personal Archive.

To validate the results, we used the literature review on the benefits of a lighting control system. We reviewed books, articles and dissertations published from 2011 made available through google books and academic.

2.2 Data Collection Procedure

For inspection of the illuminance levels of the study site, it was based on the parameters of NBR 5382 for verification of interior illuminance in environments, in rectangular spaces with two or more continuous lines of luminaires, which is the subject of this study. With the aid of the digital luxmeter, illuminance levels were collected at four points of the room. Complementing the information on the quantitative aspects of the research, the levels of electricity consumed in a 10-hour workday were also collected.

It was also used a questionnaire with 13 closed questions and 3 multiple choice questions, applied to the room staff, specifically in 9 employees. With this instrument, it was possible to point out some qualitative aspects of the research.

2.3 Data Analysis

For data analysis, due to the complexity of the results, we chose the quantitative / qualitative approach to analysis. Divided into two stages, the quantitative data were first analyzed using tables, tables and graphs, the results from the illuminance inspection and the application of the questionnaire. Finally, the second stage deals with the benefits that the Arduino prototype can provide for the environment under study, it deals with physical, cognitive and psychological aspects.

2.4 Materials Used

Table 1. Materials used for prototype development

Hardware	Quant.	Software
Jumper Cables	11	Arduíno IDE
1KΩ Resistor	1	Eclipse
GY-2561 Light Sensor	1	Matlab
ESP8266 ESP-01 Wifi Module	1	C++ Language
Arduíno UNO R3	1	Java Language

Fonte: Próprio autor, 2019.

3 Theoretical Reference

3.1 Lighting in the workplace

The work environment is composed of a set of interdependent factors that act directly and indirectly on people's quality of life and the results of their work. In this sense, lighting is very important for an adequate level of comfort, health, satisfaction and safety at work (PAIS, 2011).

Workplace lighting, also called service lighting, is the use of light to become an easier activity to perform. It is the ratio between the luminous flux that affects a surface per unit area measured in lux (TREGENZA; LOE, 2015).

The term luminous flux (ϕ) is characterized by the amount of light emitted by a light source per second in all directions, having Lumen unit (lm). The ratio of the luminous flux that falls under the square meter of an area is defined by illuminance (E), has Lux unit (lx) (ABNT, 2013).

In this context, the use of artificial lighting is the most common in work environments, is directly related to the use of lamps and luminaires, whether indoors or outdoors. However, for a lighting project a technical analysis is made to determine the most appropriate type of lamp, taking into account the beam angle and the uniform distribution of the distribution (CORRÊA; BOLETTI, 2015).

According to Bakman (2018, p. 9) for project and lighting application and in work environments “three types of artificial lighting are considered: general lighting; spot lighting; artificial lighting ”. As illustrated in the following figures.

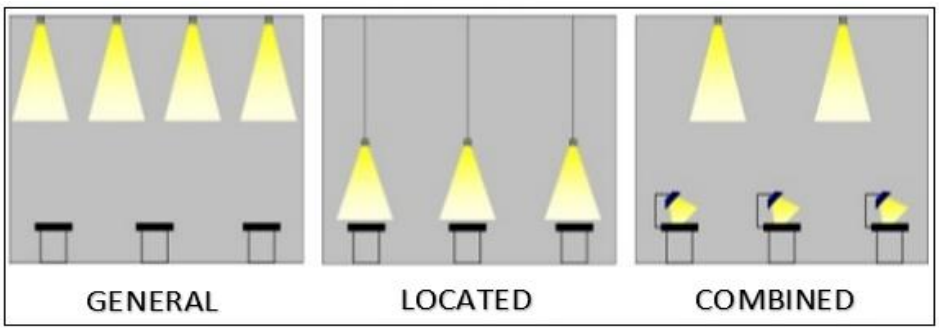


Figure 2. Types of artificial lighting

Source: Bakman, 2018.

Office activities involve a wide range of tasks, including working on display, telephone, scanner, photocopier and sending equipment, receiving e-mail and faxes, viewing documents, reading texts. , communication with coworkers. To perform their tasks, the worker has to use, among others, the visual system, one of the most important systems of our body (HENRIQUES, 2014).

In environments that require visual tasks such as reading or typing, common office activities, there is often a requirement for uniformity of illuminance standards throughout the area itself, usually including desks or, if work positions are not fixed, the horizontal work plan as a whole, the uniformity required will depend on the particular visual tasks and the situation (TREGENZA; LOE, 2015).

Thus, the study is based on inspection, measurement and suitability of work environments, in specific offices that is the subject of the research, the 2013 NBR 8995-1, which deals with the specifications and requirements for lighting in the workplace. for people who perform visual tasks.

According to NBR 8995-1 (2013, p. 27) the criterion for light level evaluation "is the point-to-point measurement in the different tasks and the comparison with the minimum required values corresponding to the minimum illuminance value for specific tasks".

Based on the minimum illuminance values specifically in the office that is the object of study research, will be used the NBR 8995-1 with the values of each activity, as detailed in the following table

Table 2. Minimum illumination levels E (Lx)

OFFICES			
TASK OR ACTIVITY	***E (LX)***	***IRC/RA***	**COMMENTS**
Archiving, copying, circulation etc.	300	80	
Write, type, read and process data	500	80	See note*
Technical drawing	750	80	
Computer Aided Desing Station	500	80	See note*
Meeting and conference room	500	80	Controllable lighting is recommended.
Reception	300	80	
Archive	200	80	

Fonte: Adaptado ABNT, 2013.

For light evaluation after installation, or for technical report issuance, NBR 5382, which deals with the verification of interior lighting, describes how to check the average interior illuminance in rectangular areas on a horizontal plane, this measurement is made by middle of the lux meter, illustrated in the following figure.

Figure 3 - MLM-1020 Digital Luxmeter
Source: Bakman 2018

* There may be exceptions to the overall reproduction rate for high mount lighting (over 6m) and for outdoor lighting when there are no people working for long periods or when color identification is required for safety.

Currently, the lighting system of a work environment is quite complex and can not take into account only quantitative aspects, it is necessary to promote qualitative aspects so that along the workday, can create stimuli and situations of relaxation and visual comfort (PARIS). , 2011).

In this context, visual comfort is linked to the set of conditions of a given environment, whose individual develops visual tasks with accuracy and precision, with less effort and less risk of injury, including risks and accidents (HENRIQUES, 2014).

Therefore, it is important to pay attention to these aspects of lighting to be most effective for both users and energy savings when it is designed to fit the function and layout of the room and the characteristics of the people who will use it.

One of the tools that has gained prominence in the market is automated lighting systems. This concept has been of fundamental importance in systems that aim to optimize procedures. A lighting system aims to provide adequate lighting, avoiding waste and maximizing the health of people at work (LOPES, 2018).

It is sometimes interesting to offer users ways to adjust the level of illumination over their individual work plans. Individuals can adjust their luminaires if they feel the need to increase or decrease the lighting relative to their surroundings, varying it according to activity. The feeling of being able to control your work environment is important for professional satisfaction and company performance (TREGENZA; LOE, 2015).

A lighting control system is an intelligent network-based solution that incorporates programming language communication between various system inputs and outputs via illuminance control-related sensors using one or more computing devices, one of which is simple and practical with low power consumption and low implementation. and maintenance costs (PARIS, 2011).

3.2 Prototype of artificial lighting control system

The design of the lighting control system had its electrical characteristics the 127V circuit, where a power line for the prototype in Arduino was created. This power supply worked from a common source that lowers the voltage from 127V to 12V as per Arduino Uno R3 specifications.

Arduino® is an open source electronic platform based on simple hardware and software. They perform input readings and turn them into output by performing some command. All these commands are executed through a set of instructions sent to the microcontroller on the board, using the programming language and the processing-based Arduino® (IDE) software (OLIVEIRA; ZANETTI, 2015).

The code installation in Arduino is the reading of the C ++ language is done through a server that communicates with Arduino through the ESP8266 ESP-01 WiFi module, powered by a 5V output of Arduino itself. To program Arduino, we use the Arduino IDE itself (Figure 3), a free software program in the Arduino understands language (inspired by C language). The IDE allows you to write a computer program, which is a set of step-by-step instructions that you upload to Arduino. Arduino then executes these instructions, interacting with whatever is connected to it. In the Arduino world, programs are known as sketches (ADAS, 2017).

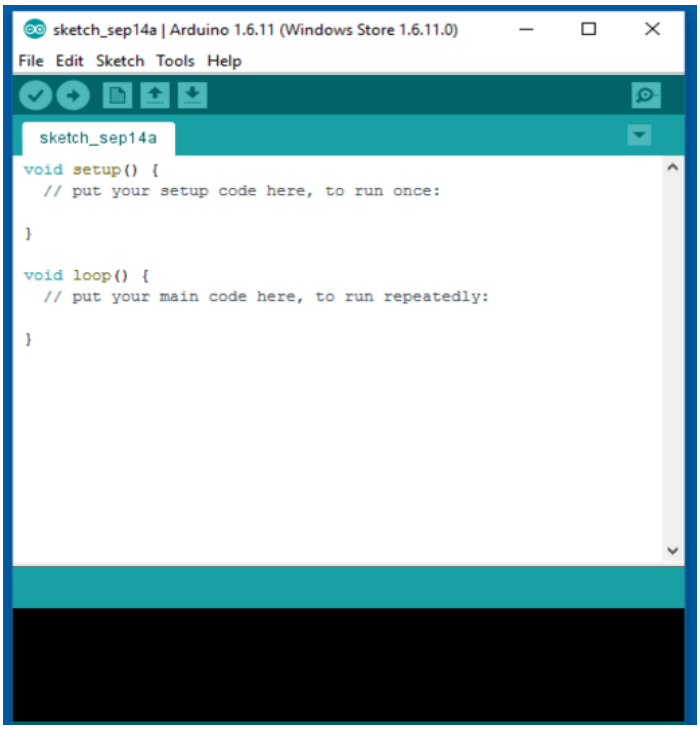


Figure 4. Arduino IDE Interface
Source: Adas, 2017.

The programming language used in Arduino® is very simple, based on C and C ++ languages, it uses a lot of libraries and resources. It has three main parts: structure, values (variables and constants) and functions. The structure is the elements of the Arduino® code, the variables are the constant data types and the functions are to control the Arduino® plate and perform the calculations (KULKARNI, 2017).

The ESP8266 (Figure 4) is a microcontroller developed by Espressif Systems, which has been on the market since 2014. Although recent, it has been gaining prominence with developers and enthusiasts due to its

small size, having a Wi-Fi communication system, standard widely used today, and also for its low cost (ARAÚJO, 2017).

Figure 5 - ESP8266 wifi module
Source: Araújo, 2017.

Protoboads (Figure 6) are one of the most important tools for assembling circuits, because it is possible to assemble numerous circuits without the need to solder components, so if there is no certainty how a particular circuit will behave during Protoboard is the most recommended place to operate this circuit and perform all necessary tests (ADAS, 2017).

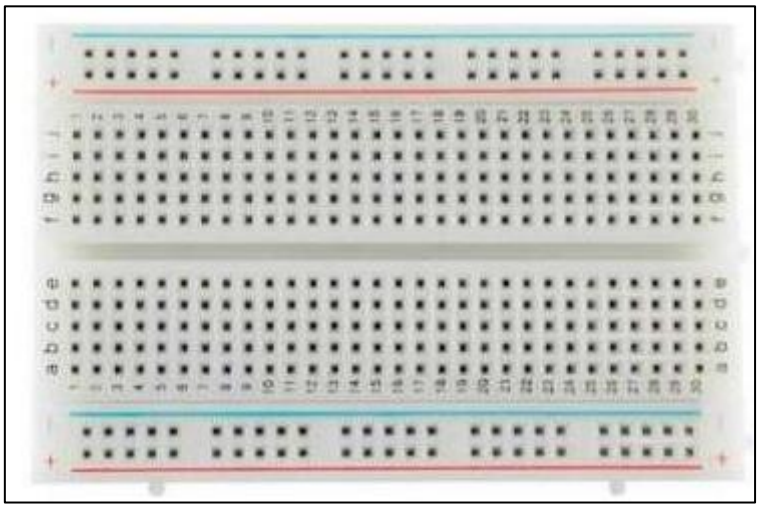


Figure 6. Protoboard
Source: Adas, 2017

The TSL2561 Breakout Light Sensor (Figure 7) is a sophisticated light sensor responsive to most of the visible spectrum. Unlike the simplest sensors, the TSL2561 measures both infrared and visible light to better approximate the response of the human eye (OLIVEIRA; ZANETTI, 2015).

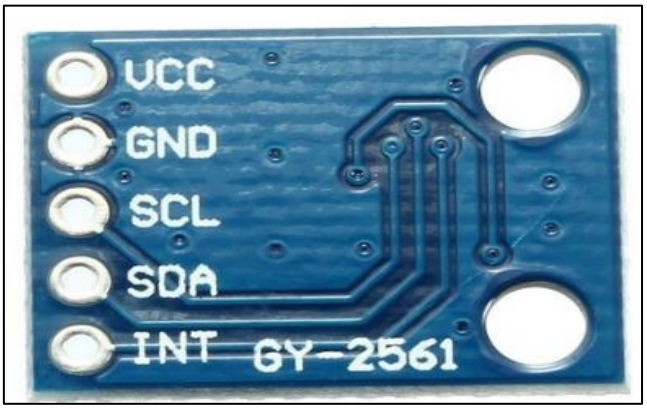


Figure 7. GY-2561 Light Sensor
Source: Oliveira and Zanetti, 2015.

A resistor or resistor (Figure 8) is a widely used electrical device in electronics, sometimes for the purpose of transforming electrical energy into thermal energy through the joule effect, sometimes for the purpose of limiting the electric current in a circuit (ARAÚJO, 2017).

Figura 8. Resistor de 1KΩ
Source: Araújo, 2017.

Jumpers (Figure 9) are electrical cables or wires with ends that are properly prepared to make electrical connections between the components of a circuit enabling the conduction of electricity along it (KULKARNI, 2017).

Figure 9. Male / Female Jumper
Source: Kulkarni, 2017.

In this context, the proposed lighting control prototype is represented as the following figure.

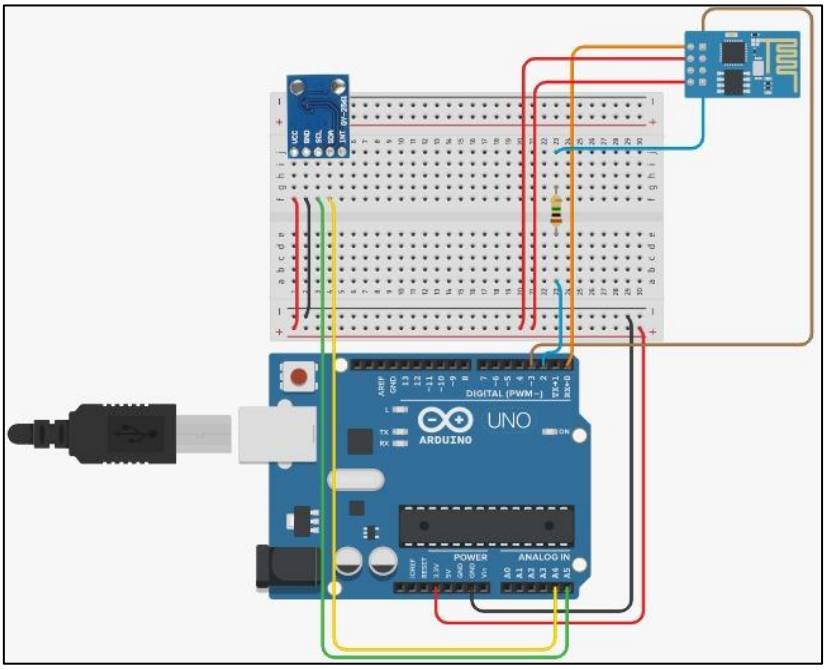


Figure 10. Lighting Control Prototype
Source: Matlab, 2019.

The prototype is very simple to operate, first the GY-2561 light sensor sends the light measurement to the Arduino through the input ports (A4 and A5), in the lux measurement unit, the Arduino then communicates with the module. wifi through its output ports (0, 2 and 3), using the data received by the light sensor, sending this information over the network to the server that will then perform the data recording, as illustrated in the following figure.

Figure 11. Lighting Control Prototype
Source: Personal Archive.

Eclipse software is an IDE for Java development, but it supports several other languages from plugins like C / C ++, PHP, ColdFusion, Python, Scala and Android platform. It was made in Java and follows the open source software development model.
The results obtained by the prototype will be available on the computer screen through the "Web Screen" which uses PHP programming language that allows access through any device with internet access. An outline of what the screen will look like is illustrated by the following figure.

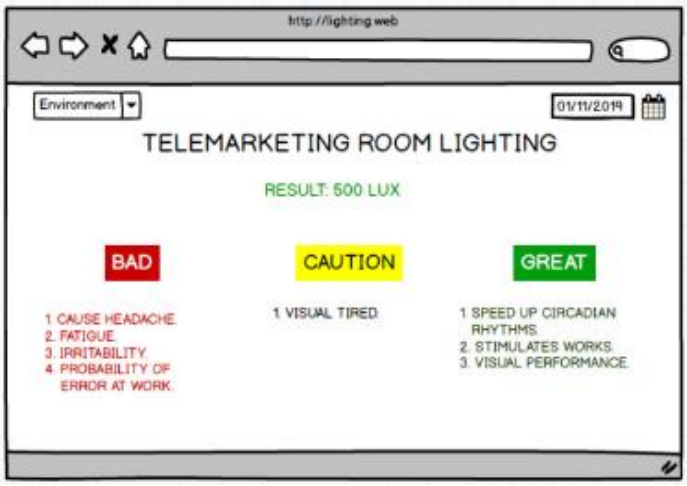


Figure 12. Web screen
Source: Matlab, 2019.

4 Results and Discussions

4.1 Quantitative Research Data

The results obtained in the illuminance inspection are described according to the following table.

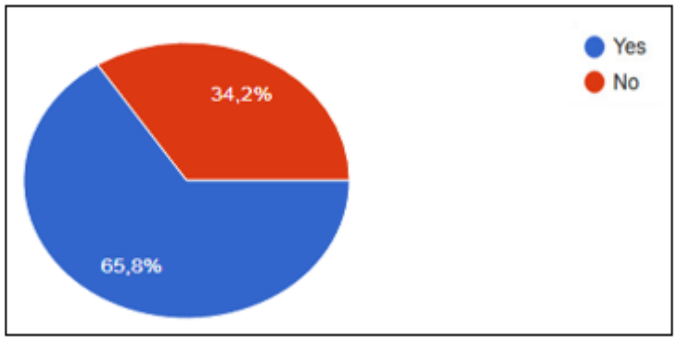
Table 3. Illuminance levels inspection results

Score 1	564 Lux
Score 2	410 Lux
Score 3	389 Lux
Score4	592 Lux

Source: Own author, 2019.

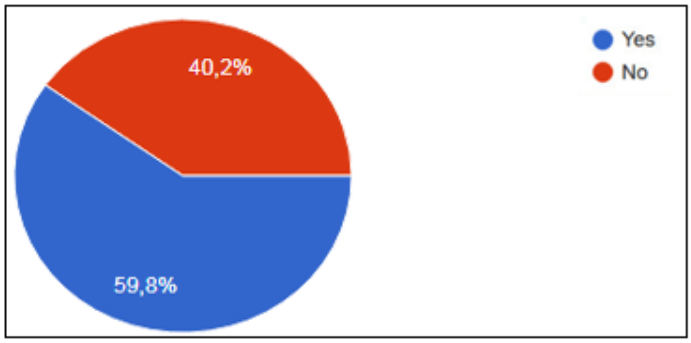
It is observed that the level of illuminance in the workplace studied are outside the standard specified by NBR 8995-1, which was found in the application of the questionnaire assessing workers' satisfaction with lighting in the workplace, as shown by following results.

At first it was asked if the lighting is being evenly distributed in the work environment. The result shows that 65.8% of respondents think yes and 34.5% think no, as shown in the following chart.



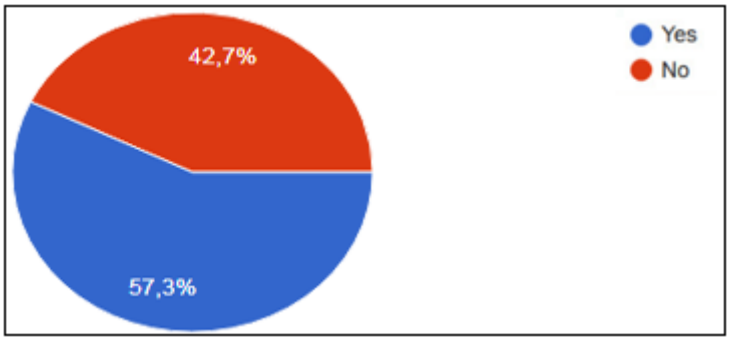
Graph 1. Evaluation of lighting distribution
Source: Own author, 2019.

Another aspect asked was about the lighting presenting some kind of shadow or glare. As illustrated in the following graphic.



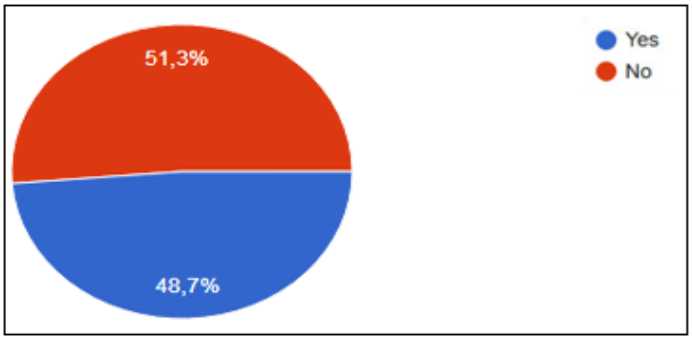
Graphic 2. Illumination with shadows and glare
Source: Own author, 2019.

The graph shows that 59.8% of respondents have some kind of shadow or glare problem at work.
It was also asked if the worker has any symptoms of eye irritation, redness or tearing after the workday, as illustrated in the following graphic.



Graphic 3. Symptoms of irritation, redness or tearing
Source: Own author, 2019.

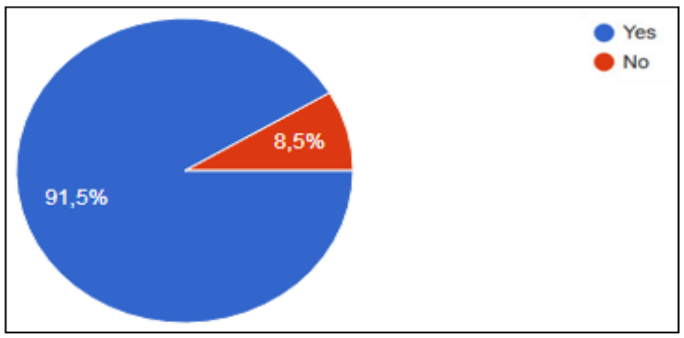
The results showed that 57.3% of respondents have some kind of eye symptoms after the workday and 42.7% do not experience any of these symptoms.
Another important fact of the research was in relation to workplace accidents arising from low lighting, the following graph shows the following results.



Graph 4. Work accident from low light
Source: Own author, 2019.

The results show that 51.3% of respondents did not suffer accidents from low lighting in the workplace, and 48.7% already had some type of accident in the workplace from low lighting.

Finally, we were asked about the indication of the implementation of a lighting system in the sector studied, the results are illustrated in the following graph.



Graphic 5. Indication of a luminosity system
Source: Own author, 2019.

The results show that 91.5% of respondents felt positive the implementation of a brightness control system in the workplace, and 8.5% did not consider it important to have this brightness system in the workplace.

Regarding the prototype performance, the energy saving as a function of the lighting control system. Automation is an important factor in reducing energy consumption. Analyzing the performance of the lighting system proposed by the In this research, using it in a 10-hour journey, there is a significant reduction of 7% a.m. in energy consumption, taking into account that the prototype works only in one sector of the company that is the office. By extending this prototype to other sectors, energy savings can reach 20% a.m. on the energy bill.

Another important aspect is the low cost of the prototype presented, detailed according to the following table.

Table 4. Budget for the light control system

EQUIPMENT	QTY	PRICE
Female Jumper Cables	11	R$ 14,00
1KΩ Resistor	1	R$ 0,17
GY-2561 Light Sensor	1	R$ 19,90
ESP8266 ESP-01 Wifi Module	1	R$ 17,90
Arduíno UNO R3	1	R$ 27,89
Protoboard 400 holes	1	R$ 14,45
12V power supply	1	R$ 9,90
TOTAL		**R$ 104,21**

Source: Own author, 2019.

It is noteworthy that no information was obtained on the monthly electricity cost of the company nor access

to the electrical panel of the studied sector, therefore, it was not possible to make an analysis of the financial viability of the prototype.

From the point of view of quantitative research results, it is important to highlight that productivity depends directly on the well-being of the worker in the workplace, which is directly related to adequate illumination that provides good execution of activities without glare, shadows, sparkles. and reflexes, and other anomalies arising from poor lighting (KOVALECHEN, 2012).

4.2 Qualitative Data

The influence of good lighting is of paramount importance to the good performance of the task. Lighting should be evenly distributed, general and diffused to avoid glare, annoying reflections, shadows and excessive contrasts. With the scope of this research as a commercial office, lighting is a very relevant factor in relation to activities performed in the workplace.

The goal of a good project to control illuminance levels in the workplace is to improve crucial visual differences in brightness and color using lighting and other features (PAIS, 2011).

In this context, the prototype presented for lighting control enables automatic adjustment of illuminance for the most common office activities. Need that arose taking into account aspects related to physiological and psychological effects detected in the study environment.

The need to adapt this space, valuing characteristics such as comfort, health, safety, physical and psychological well-being, in order to make the work environment motivating and favoring the improvement of work performance activities, are factors of good equivalent lighting. the quantity and quality requirements of the resources allocated in a modern lighting control system (HENRIQUES, 2014).

Qualitative classified points correspond to three factors: physical; cognitive and psychological. The physical aspect is easily detected because it deals with the mode of operation, actions, gestures and movements to perform daily work activities. The cognitive aspect concerns reasoning, decision making, memorization, planning, elaboration and control, characterizing the intellectual side of the activity. This is complemented by the psychic aspect that is related to feelings, emotions, behavior and perception of those who perform the activity (LOPES, 2018).

The effects of good lighting according to recent medical and biological research have consistently shown that light entering the human eye has, in addition to a visual effect, also an important non-visual biological effect on the human body. As a result, good lighting has a positive influence on health, well-being, alertness, and even sleep quality. Our better understanding of the diversity of lighting effects teaches us that new rules governing the design of good and healthy lighting installations are necessary (HELIODORO et al., 2017).

Thus, visual comfort is an important factor within a lighting system. Since psychological factors such as behavior and attitudes in the workplace are related to this concept. Another factor is the improvement of visual acuity in activities, without effort and vision impairment, in the long run contributes to quality, productivity and reliability of work environment performance, which indirectly increases workers motivation (BORTOLAN, FERREIRA, TEZZA, 2019).

A good lighting system also promotes long term worker health. Some illnesses linked to office activities can be prevented such as stress, mental fatigue, physical injuries, accidents, headache, nervousness and

emotional imbalance, drowsiness and other illnesses related to workplace lighting (KOVALECHEN, 2012)..

5. Conclusion

The aim of this research was to present a brightness control system through the Arduino prototype that will adjust the brightness in the workplace according to the Brazilian norms according to the activities performed and through the bibliographic review to point out its advantages and benefits to the company and its customers. workers.

Through the data collection results, it was possible to detect some negative aspects of the lighting of the work environment under study, such as: low light levels in relation to the values stipulated by NBR 8995-1; dissatisfaction with ambient lighting and some occupational diseases.

In this scenario, the need to create an automated brightness control system is a prototype-based system in Arduino that sends information to a computer that allows the measurement of brightness in the studied environment in real time, showing the results on the screen. (Figure 10) and automatically adjusting the brightness to the values stipulated in NBR 8995-1.

Due to the complexity that surrounds a lighting control system, prototype experiments were necessary, some programming and language difficulties were very present in the prototype creation. In this context, the prototype function test was successfully performed, the results of this prototype were divided into quantitative and qualitative.

It can be concluded that from the point of view of the quantitative benefits of the prototype, it is emphasized the increase of productivity in the work environment; reduction of disease and energy costs and compliance with current standards, as well as low cost for prototype implementation.

Regarding the qualitative benefits, the importance of visual comfort, a weighting factor in office activities, is emphasized, relating benefits of character: physical; cognitive and psychological, which provides well-being, motivation and quality of life at work.

Thus, the objective proposed by the present research was successfully achieved. It is indicated the use of the material developed for future consultations in new research on the theme addressed or serving as a model for problems related to lighting in the workplace, specifically in offices or rooms based on the use of visual activity in their areas. daily activities.

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