The impact of switching from fluorescent lights to full-spectrum fluorescent and LED lighting in schools. An experiment in Victoria Int'l School in Sharjah

دراسة التأثير الناتج عن تغيير الاضاءة من مصابيح الفلوريسنت التقليدية إلى إضاءة الفلوريسنت كاملة الطيف عالية الدقة و إضاءة "الليد" في الفصول الدراسية.
تجربة في مدرسة فيكتوريا الدولية بالشارقة

by

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ABSTRACT

Human performance is influenced by lighting in many situations. Many studies have investigated how lighting impacts academic performance, focus, and motivation. The issue of color rendering and temperature is becoming increasingly important as high efficiency lamps and government regulations are enforced. For decades, fluorescent lamps have been used in educational systems to provide high-quality, efficient lighting. Fluorescent lamps can negatively affect the built environment as well as the surrounding environment. Several studies have been conducted to show that LED lamps have positive effects in the built environment.

Several studies show that LED lamps with high color temperature correlation affect perceptions and actions positively in the classroom and workplace. In the workplace and in school, it can increase engagement and on-task behavior. This study develops experimental research for effects of LED, fluorescent, and full spectrum lighting on classroom’s children. To assess various effects related to classroom lighting on children between the ages of four and seven, an online survey was developed.

During the Mother's Day morning tea celebration, a survey was conducted among three classrooms of Victoria International School's Early Learning Center. Results of the study indicate that 5000K or higher LED lighting has a significant impact on perceptions of attitudes and behaviors associated with alertness, focus, and performance in a classroom. Further experimental studies are required to evaluate attitudes as well as behaviors related to classroom illumination and how dynamic lighting affects students

نبذة مختصرة

يتأثر الأداء البشري بالضوء في العديد من جوانب الحياة ومواقفها المختلفة. وقد تناول عدد كبير من الدراسات كيفية تأثير الضوء على كل من الأداء الدراسي ، والتركيز ، والتحفيز. كما تزايدت أهمية موضوع التجسيد اللوني ودرجة الحرارة ، مع سريان القوانين واللوائح الحكومية لاستخدام المصابيح عالية الكفاءة. وعلى مدار عقود ، كانت مصابيح الفلوريسنت تُستخدم في الأنظمة التعليمية ، من أجل توفير الجودة العالية والإضاءة الفعالة؛ لكنّ مصابيح الفلوريسنت يمكن أن تؤثر بالسلب على البيئة داخل المباني وعلى البيئة التي تحيط بها. وقد أجريت دراسات عدة لإثبات التأثيرات الإيجابية لمصابيح الإضاءة "الليد" على البيئة داخل المباني.

وتُظهر العديد من الدراسات أن مصابيح الإضاءة "الليد" ذات الارتباط بدرجة الحرارة المرتفعة ، تؤثر على عمليات الإدراك والتصرف بشكل إيجابي ، داخل الفصول الدراسية وفي مقرات العمل ، كما يمكن أن تؤدي مصابيح الإضاءة "الليد" إلى زيادة المشاركة والتركيز على مهام العمل في مقرات العمل وفي المدارس. وتقدم هذه الدراسة بحثا تجريبيا لتأثيرات مصابيح الإضاءة "الليد" ، ومصابيح الإضاءة الفلوريسنت ، والإضاءة كاملة الطيف على الأطفال داخل الفصول الدراسية. كما عملنا على تقديم مسح على الإنترنت ، من أجل تقييم تأثيرات الإضاءة داخل الفصول الدراسية على الأطفال ، بين عمر أربع إلى سبع سنوات.

خلال الاحتفال بشاي الصباح بعيد الأم ، تم إجراء استبيان على ثلاثة فصول دراسية في مركز التعليم المبكر بمدرسة فيكتوريا الدولية. وقد أشارت نتائج الدراسة إلى أن 5000 ك أو أكثر من الإضاءة بمصابيح "الليد" تؤثر بشكل إيجابي على إدراك وسلوك الطلاب ، فيما يتعلق بالانتباه والتركيز والأداء داخل الفصول الدراسية. وإضافة إلى ذلك ، يجب إجراء الدراسات التجريبية لقياس المواقف والسلوكيات التي تتعلق بالإضاءة في الفصول الدراسية ، ومدى تأثير الإضاءة الديناميكية على الطلاب.

DEDICATION

It would not have been possible to write this thesis without the help of several people.

I am deeply grateful to My parents, **JAMAL** and **SOHA** who have provided encouragement, guidance, and support throughout my life, I would like to thank them for providing me with encouragement and support throughout this writing process. Thank you for supporting me, throughout my life, in my determination to reach my full potential and contribute to the world.

NAJWA and **RAMA**, my faithful sisters and partners who have always been there for me and I can always count on them for help...

Dear **AYAD** who is willing to engage in the Feelings of discomfort when a partner refuses to accept her role as "Housewife" and who is Aiming for redefine and redesign it. You have been a great assist as I've combined A woman's role as a mother and a wife with the responsibilities of management, work, and continuing education. Your assistance is greatly appreciated.

My children deserve my sincere gratitude, **TELIA, SAFA**, AND **JAD**, for their support, even when being 'without Mum' was difficult, and for their assistance with the surveys and studies. You and all future generations are the beneficiaries of this work.

I also dedicate this work to **ELAF** - my friend, 'soul sister', partner, and researcher - who has knowingly and unknowingly led me to understand some of the difficult and subtle challenges we face in order to thrive.

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Particularly, I wish to express my appreciation to both my supervisor **(Prof. Wael Sheta),** who spared no effort to ensure my success, and our Head **(Prof. Bassam Abdul-Karim Abu-Hijleh).** As a student at BUID, I had the privilege of having **(Prof. Hanan M. Taleb)** as a mentor who provided me with inspiration and support throughout my studies.

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It is my pleasure to thank **Mr. Khan Ikram** who has been responsible for maintenance at Victoria International School for providing me with all the information I needed regarding the original lighting in the school and also for providing me with the plans I requested.

Last but not least, I would like to take this opportunity to thank every member of the **staff at Victoria International School** who has been so helpful and kind to me.

In conclusion, I would like to thank **the teachers and administrators** at the **British university in Dubai**

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1. INTRODUCTION

1.1 Background of the Study

The majority of lighting practices today are focused on visual aspects (Ticleanu,2021). Additionally, in a number of sectors, including lighting for classrooms, there are also aesthetic requirements in order to improve the appearance of places, persons, and objects. This ties in with what one would assume to be the primary function of light - supporting visual perception and satisfaction via the provision of appropriate lighting for safe, accurate, quick, and comfortable performance of human duties. Furthermore, light can also affect human physiology in ways that are not visual or perceptual (Boyce,2014). the World Health Organization has defined that, wellness is more than the absence of disease and infirmity, it includes total social, physical and mental wellness (Schalangen,Smolders and Plischke, 2014). The circadian rhythm is affected by light, which regulates a number of physiological processes and behaviors ranging from immune reaction to appetite. As a result, human circadian rhythms are largely controlled by light (Schalangen,Smolders and Plischke, 2014). In order to achieve circadian entrainment and maintain regular sleep–wake cycles, bright daytime light combined with darkness at night is essential. However, constant exposure to light in the evening can adversely affect sleep patterns and have a detrimental impact on morning wakefulness. Additionally, lighting can also have effects that may not be clearly visible on aspects such as mood, alertness, and attention (Boyce,2014).

1.1.1 Lighting Significance in classroom

In order to achieve lighting that ensures students and staff can carry out their four specific activities in a stimulating and appealing environment, the lighting design of a school should provide appropriate lighting environment for students. To create a school environment that gives a sense of comfortable living, attractiveness and pleasure, ambient or natural lighting plays an essential, if not primary, role (Ticleanu, 2021). Additionally, a well-designed lighting system contributes to student satisfaction and well-being. Adequately designed lighting systems can also contribute to enhancing the alertness and encourage the students to carry out their school responsibilities. Lighting design for classrooms plays a crucial role in achieving good circadian entrainment for students as it has a significant effect on the circadian rhythm among children and adolescents (A.Wilkins, 2009).

Research by (Meyano, Lezcano and Fernandez, 2020) analyzed publications in this particular field in order to examine the effects of blue light on the retina. This information was used to evaluate the spectral composition and irradiance of the LED luminaries, as well as examining the light produced by digital devices on children. The results discovered that the amount of blue light produced by luminaries is significantly greater than the amount produced by electronic equipment, and highlighted its importance in maintaining a good circadian rhythm for students by providing sufficient lighting in classrooms.

1.1.2 Required lighting levels in classroom

The following figure (Figure 1) states the needed illuminance values by CIBSE for different areas in schools to prevent distracting contrasts and distractions. According to

the CIBSE code of interior lighting for public and educational buildings, a value of 500 lux is recommended for areas where task-intensive activities will be carried out and one third of that value is suggested for the surrounding area.

		Standard Maintained Illuminance lux	Uniformity Ratio	Limiting Glare Index
1.	General Teaching Spaces	300 *	0.8	19
2.	Teaching Spaces with close and detailed work (eg, art and craft rooms)	500 *	0.8	19
3.	Circulation Spaces: corridors, stairs	80 - 120	-	19
	entrance halls, lobbies & waiting areas	175 - 250	-	19
	reception areas	250 - 350	-	19
4.	Atria	400 *	-	19

Figure 1 A comparison of illumination, uniformity ratios, and glare limiting indices for schools. (CIBSE 2018).

Likewise, in the Illuminating Engineering Society of North America (IESNA) handbook, it is recommended that the horizontal illuminance value of a typical classroom be set between 600 lux and 800 lux as showing in figure 2.

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.		
A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)
Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.		
D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)
Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.		
G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

* Expected accuracy in illuminance calculations are given in Chapter 9, Lighting Calculations. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be with ± 10% of the recommended value. It should be noted, however, that the final illuminance may deviate from these recommended values due to other lighting design criteria.

Figure 2 Determination of Illuminance Categories (IESNA 2017)

1.1.3 Lighting Quality

Lighting quality is a term that describes the quality and effect of light as it relates to the formation of images in terms of building lighting. It is one of the least understood aspects of lighting in the building environment (Veitch and Newsham, 2013). Since lighting quality is a very broad and ambiguous concept, there is little consensus among lighting professionals on what it exactly refers to (Boyce, 2013). According to the term's original definition, it describes all the components of a lighting system that are not directly associated with the amount of light (Veitch, 2013).

As a consequence of this, many different definitions have been proposed, including: "A key characteristic of good lighting is the capability of allowing people to see with ease, without causing all kinds of discomfort to their eyes, and instead raises their spirits" (Boyce, 2014). While there are a number of different definitions, they do not provide direct information on the way lighting quality can be measured. In order to improve the understanding of lighting quality, a consensus must be reached on a method that can objectively determine lighting quality. This will allow further research to relate photometric measurements to subjective responses (Newsham and Veitch, 2000). Based on a more thorough understanding of lighting, recommendations can then be developed that can be incorporated into requirements and standards, resulting in high quality lighting. IN the figure 3, published by (Samanji, 2012) highlights the different elements that are integral to overall effects of lighting quality.

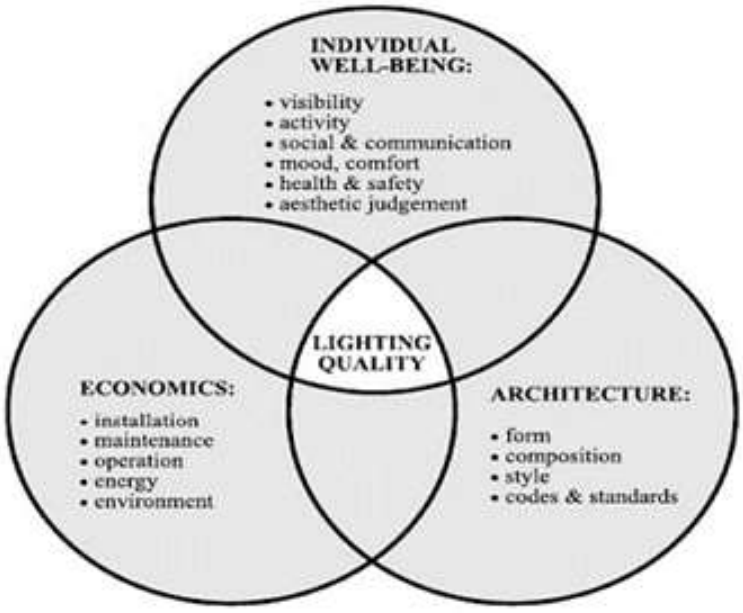

Figure 3 Elements for lighting quality (Veitch 1998)

1.2 Aims & Objectives

The purpose of this study was to review the effects of classroom lighting on students. Next, we aimed to determine the most suitable luminaires based on the recommended circadian light as well as the recommended light levels for classrooms in order to provide further recommendations and guidance to architecture and lighting Engineers. This research will examine several parameters of circadian light based on the results of previous studies.

Human health is one of the most important aspects of our lives, as it helps maintain a positive psychological state which enables us to be efficient, attentive to others and our environment, while allowing us to be creative (Nelson, Walker II and Bumgarner, 2021).

There is a wealth of previous research on Circadian Rhythm as a primary subject considering its importance on the well-being of humans, both psychologically and physically. These publications have highlighted how human health and productivity are positively impacted by maintaining a healthy circadian rhythm (Noruzi, Shiraseb, Mirzaei and Mirzababaei, 2022).

Generally, a "luminous environment" study has been focused on the development of luminaires which perform efficiently and produce high color rendering to meet the visual needs of observers. Alternatively, studies have been conducted to study the non-visual effects of luminous environments on observers, and in response luminaires have been developed that address psychological as well as physiological aspects (L.Amundadottir, Rockcastley, Khanie and Andersen, 2017). Evidence has shown a correlation between the brightness of a luminous environment in an indoor workspace and working efficiency – it was found that excessive glare caused by luminaires can contribute to discomfort or impairment of vision for observers. As

well as being able to provide psychological stability through luminous environments indoors, lighting environments are capable of stimulating the brain and affecting the hormones and biorhythms of occupants depending on their wavelength, intensity and exposure tie (Zheng,Wu, Gao,Wang, Zhu and Lu, 2016). A particular example which highlights this is a study published by (Hamner, Bierman, Figueiro and Rea, 2011) where observers perceived a light environment where the color was almost blue. This was shown to set off a circadian action factor (CAF,ACV) that represented the impact of light on hormones and biorhythms of observers who perceived the environment as blue. As a result, melatonin production was then shown to be suppressed (Hamner, Bierman, Figueiro and Rea, 2011). Melancholia, sleep disorders, and developmental difficulties can all be related to the suppression of melatonin. As a result, when designing an appropriate indoor luminous environment, it is necessary to accurately predict the color perception of a space and to pay careful attention to potential effects on an observer.

Researchers stress the importance of circadian light as one way to promote good circadian rhythms, which improves the health of the general public. Furthermore, connecting body structures to quantitative metrics requires cooperation among researchers in the health sector as well as lighting specialists, designers, and engineers. This research was conducted with artificial lighting since the available information is limited when it comes to determining the effects of various forms of lighting on circadian rhythms.

The primary purpose of this study is to analyze the color calculation methods and the color rendering methods used by two representative software programs to simulate luminous environments (DIALux evo and AGI32).

Along with its primary objective, this study also sought to:

- Assess the visual comfort of classroom lighting

- Determine the minimum intensity of lighting necessary for a specific location without compromising lighting quality.
- Measure the lux level in learning areas.
- Design a classrooms lighting and measure the school's energy performance so that the school administrators can optimize performance by reducing energy consumption.
- Calculate how much energy is needed to illuminate the educational facility.
- Identify the impact of luminaires on the circadian rhythm of students.
- Investigate how the interior finish color affects their mood and cognitive ability based on the gender and age of observers.

1.3 Scope of the Study

Since the formal education system in the United Arab Emirates (UAE) is still in its infancy, reforms are likely to be made within a relative fast timeline. In the 1970s, school buildings increased in number as development in the UAE progressed at a fast rate. The UAE Interact published a report in 2010 stating that there were approximately 1,500 high schools and primary schools in 2004, with just less than 35,000 students attending these schools. Previous analysis has been conducted over 15 years ago and is able to provide some statistics on the number of school children in the current year. In order to ensure that the needs of school children are met, the UAE government provides a strong and supportive system to meet effective regulations. This is due to the leadership and government entities holding the belief that investment in the education of young individuals is an investment in the future of the UAE.

In order to determine the effects of lighting on industrial workers, several types of research has been conducted. However, very little data has been gathered on the effects on school aged children. This could be due to factors such as the movement habits of young children being

unpredictable and as a result changing the results of a given experiment and rendering the research inconclusive. Additionally, some of findings may not apply across settings because students often don't have the same tutor for the entire period, and variation in tutors use different teaching methods when they teach could all have potential effects on results.

Investors, researchers, shareholders, manufacturers, policymakers, and government entities will greatly benefit from this study. In addition to encouraging schools, organizations, and researchers to be fully committed to the ideals of their profession, this study aims to provide results which will result in positive impact on education. In addition, a guide will be provided to school administrators as to how to best direct the school's resources towards enhancing the visual comfort of the students. Moreover, the findings will also be useful to other research students who are interested in doing further research in the future on the subject matter. Despite the population of students in schools continuously increasing while there is no apparent change in the physical environment, it is imperative that schools focus on improving the academic performance of their students and adequate lighting environments can play an important factor in this regard. Finally, the information gathered from this study could also be a useful tool for the government by enabling them to employ trained personnel with sufficient resources for efficient implementation of policies to help student success.

Findings of researchers done over the years have conclusively determined that student performance can be affected by external conditions such as the state of the buildings, color, and lighting. School administrators constantly request financial aid to improve their educational facilities. It would helpful if they were able to show that the environment is a factor in the learning process. Changes to the educational facility, whether it is structural or lighting, must

aim to improve the performance of the students. (Lemasters,1996) opines that when students are in a comfort environment, they tend to do better than if there are in an unsuitable environment. This is similarly supported by (Blair, 1998) who states that there is a significant correlation between the standard of the school facility and the student's learning process.

This study is undertaken to empirically analyze the effect of lighting on classroom's children. The study used primary data by observing students in their learning environment without obstructing their academic progress. The study also utilized secondary data that were extracted from the internet. It is hoped that school administrators, architects, and the UAE government will review this report, and its effect will be seen in the design of educational facilities in the future.

1.4 Research Delimitation and limitation

This study is concerned with the impact of lighting on students in classrooms. The environment, in this sense, comprises of:

- The physical production environment: The school's physical environment is a huge factor in the learning process. This refers to not just the lighting but the noise & air quality and temperatures the students might be exposed to. It also refers to the state of the facility. If the facility is welcoming and safe, absenteeism by teachers and students will be minimal as everyone will be excited to come to school. When the environment is clean and conducive for learning, the learning process can be better facilitated.

- The community environment: Connecting with the community should not be overlooked as it is considered a critical process for transforming the school facilities and a great way

of pressing demands on the government. Children are more likely to stay in school if there is a fluid collaboration between the school authorities and the community members.

- Socio-economic status: There is a definite relationship between the socio-economic status of the family and the ability of the children in that family to learn and assimilate information. This means that the home environment can play as much role as the school environment in educating the child. While the effect of the socio-economic status of the family on the child's learning might be insignificant, the level of education, the parents have attained plays an immense role.

Although the study was designed to cover all of its aims and objectives, despite our best efforts, some limitations were unavoidable. First, this study is intended to students in the selected school due to the number of resources. The educators interviewed during this research were less than 19% of the entire population which would mean some schools were underrepresented. Additionally, some of the responses of the school personnel also appeared to be biased. Whatever the challenges, it is not possible to identify every environmental and physical factor that may have an impact on students' learning. The lack of data obtainable offline and online was significant drawback as it made the effect difficult to determine. The exorbitant cost of transportation to and from the school was a hindrance to the speed of this research work. Finally, this study was limited as it focused majorly on discovering the impact of classroom lighting on children and unfortunately could not cover the scope of providing practical advice with regards to replacing the existing lighting system with full-spectrum and LED lighting in both classroom and industrial buildings.

1.5 Dissertation Outline

This dissertation consists of six chapters and organized in the following manner:

Chapter One - Introduction: Includes a background of the study, statement of the problem, aims & objectives of the study, research questions, scope of the study, the significance of the study, delimitation, limitation, assumptions, and operational definitions.

Chapter Two - Literature Review: In this chapter, valuable insight into the present condition of school facilities as evidenced by researchers will be provided, the lighting conditions of these facilities, and determine the correlation between these factors as it concerns the academic achievements of these students be analyzed.

Main parameters that impact lighting conditions are briefly described. Relevant published articles about each of the parameters are briefly reviewed.

Chapter Three - Methodology: In this chapter, the subjects and its demographics are described, instruments, data collection, observations, design of the study, the preferred investigation method- the subjective study and parametric study is well defined in this chapter.

Chapter Four – The Experiment: This chapter presents descriptions and explanations of the findings driven by the research questions of this study that will determine how different the full-spectrum lighting is from fluorescent lighting and how it affects the learning process in classrooms by comparing it with the effects of adequate daylight. The results focused on these performance indicators as evidence of school effectiveness.

Chapter Five – Analysis and Discussion: In this chapter, the summary of results was discussed along with the conclusions by the researcher and associated recommendations related to the study and for further study.

Chapter Six – Conclusion and Recommendations: The result of the analysis and discussion will be summarized in a report with comments on the findings, results, and discussion. Additional suggestions will also be made based on the report findings as well.

2 CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Throughout this chapter, we aim to identify the gaps in understanding of this topic that we currently possess, and we will also give an overview of available research and knowledge on human-centered lighting. First, we will discuss human-centered lighting. Secondly, we will explore the concept of circadian rhythm and its relationship to light. Besides describing how light affects humans in ways that are not apparent, this article also discusses circadian light, its metrics, and the codes and standards that apply. This chapter will provide an overview of lighting design in classrooms and how to design artificial lighting in classroom while taking circadian light into consideration.

2.2 Daylight Theory

There are a variety of examples of natural lighting in nature, such as sunlight, moonlight, and stars. It is an important source of light for human vision adaptation and is also known as daylight (Rizal, et al., 2016). There are a number of factors that influence the amount, quality and distribution of daylight in a space (Gupta et al., 2015). There are many factors which contribute to the illumination of a space through the use of windows and openings (Sun et al., 2017) and different methods used to evaluate daylight quantity, including the Daylight Factor (DF) (Sun et al., 2017; Liu et al., 2019), although illuminance level can also be used (Hourani & Hammad, 2012).

It has been hypothesized that a good light quantity can be defined as the amount of daylight falling from any given working plane height, and that a good light quality can be defined as the

level of uniformity in the light and the level of glare (Axarli & Meresi, 2008). There are other factors that can affect the quality of daylight apart from the quantity of daylight and Figure 10, depicts the daylight quality design process in the sustainable developmental context. It is also important to consider the proportion of low light in the light distribution, as well as glare and the color of low light (Pellegrino et al., 2015; Liu et al., 2019).

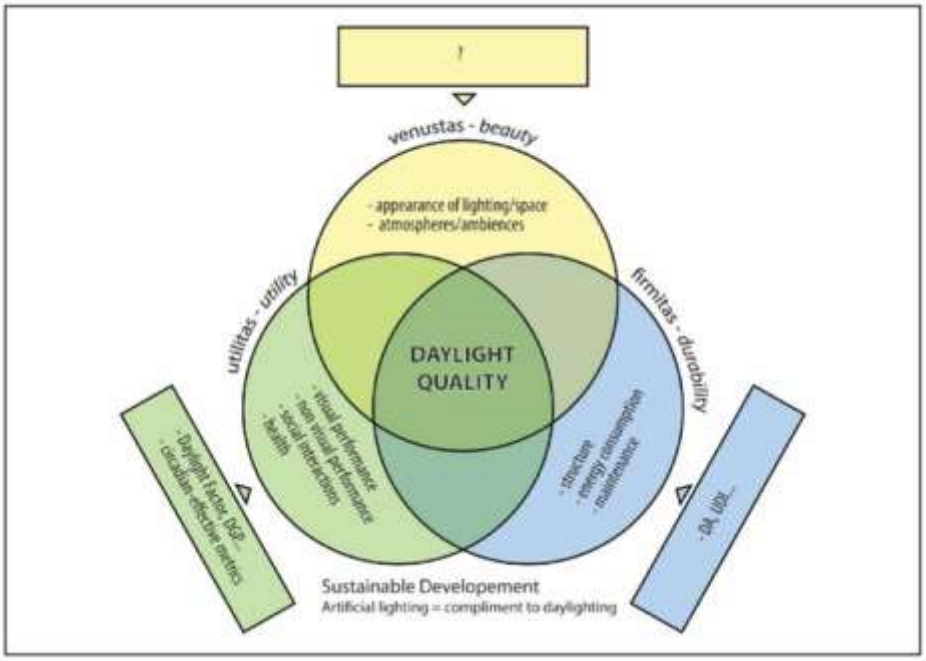

Figure 4 Daylight Quality Design process in the sustainable development context, (Cauwerts and Bodart, 2013)

Studies of daylight tended to focus mostly on the quantity of daylight in the past, but today, the quantity of daylight is considered to be a good measure of daylight quality (Jovanovic, et al., 2014).

2.2.1 Daylight factor and illuminance level

A measure of Daylight Factor can be calculated based on the sum of three components: Illuminance = SC + ERC + IRC, where the sky component (SC) is direct light from an area of sky visible from the measured point, As shown in Figure 11, the

externally reflected component (ERC) refers to the light that reflects off an outside surface and reaches the measured point, while the internally reflected component (IRC) is light entering a room through a window and refracting off internal surfaces before reaching the measured point (Rizal, et al., 2016).

According to (Darula & Kittler, 2004) the general formula calculation of zenith luminance is a reliable method of identifying dynamic daylight situations under all sky conditions. Daylight Factor (DF) is a ratio of outdoor light intensity and indoor light intensity, which is determined based on a variety of factors, including the climate, sky conditions, etc.

During recent years, researchers have used the illuminance levels to determine the amount of daylight in a given area. The luminosity emittance, luminosity exitance, or illuminance is the luminance of a surface, where the surface is the working plane for the space's main functions (Starling & Woodall, 1956; Long, 1994). The photometric study states that it measures how much incident light illuminates a surface, which correlates with subjective perception of surface brightness (Ohno, 2005). This theory of illuminance is shown in Figure 11.

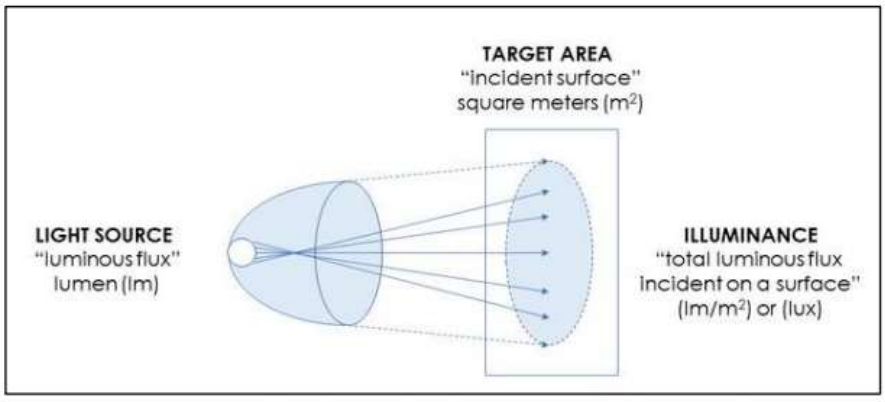

Figure 5 Illuminance in photometry and photography (source: Jrh.main, 2018)

2.3 Daylight Effects

2.3.1 Daylight effects on human circadian Rhythm

As well as the circadian clock, there are other clocks in organs and cells throughout the body that must be synchronized so that the body can function properly. This cell type is known as the intrinsic retinal ganglion cell (ipRGC) and is expressed a pigment known as melanopsin. This function of melanopsin involves sending signals to the suprachiasmatic nucleus, which controls the circadian clock. This is because melatonin is synthesized in the pineal gland during periods of darkness, and the hormone is then transported through the bloodstream and used as a chemical messenger by other clocks in the body (Boyce, 2014). In addition to being a chemical messenger, melatonin can also be used by the body as a biological marker to establish its circadian rhythms. Many factors affect circadian rhythms, including diet and exercise, but several studies suggest that light exposure is the most important contributor to the timing of these beats (Rea, Bierman, Figueiro and Bullough 2008). Despite the lack of luminance, the circadian clock's timing persists for a longer period than 24 hours in the absence of light, which over the course of time can bring various adverse effects including difficulties sleeping which will affect attention and concentration (Okawa & Uchiyama, 2007).

The concept of Circadian Rhythms has been viewed by some authors and scholars and the effects of daylighting on an individual's psychology is shown in Figure 12, (Samuels, 1990) states that our circadian rhythm is controlled by the light falling on the retina and transmitted to the hypothalamus, and it was responsible for synchronizing our internal clock to 24 hours. The circadian rhythm is approximately a 24hour cycle in a human's biological processes, and it is modulated by external factors such as sunlight and

temperature. The sunlight, when absorbed by the eye, stimulates the production of the hormone melatonin. Melatonin, a secretion from the pineal gland, plays a critical role in sleep due to its calming and soothing effects. The secretion also stimulates the production of cortisol, which serves to breakdown carbohydrates for sugar for bodily functions.

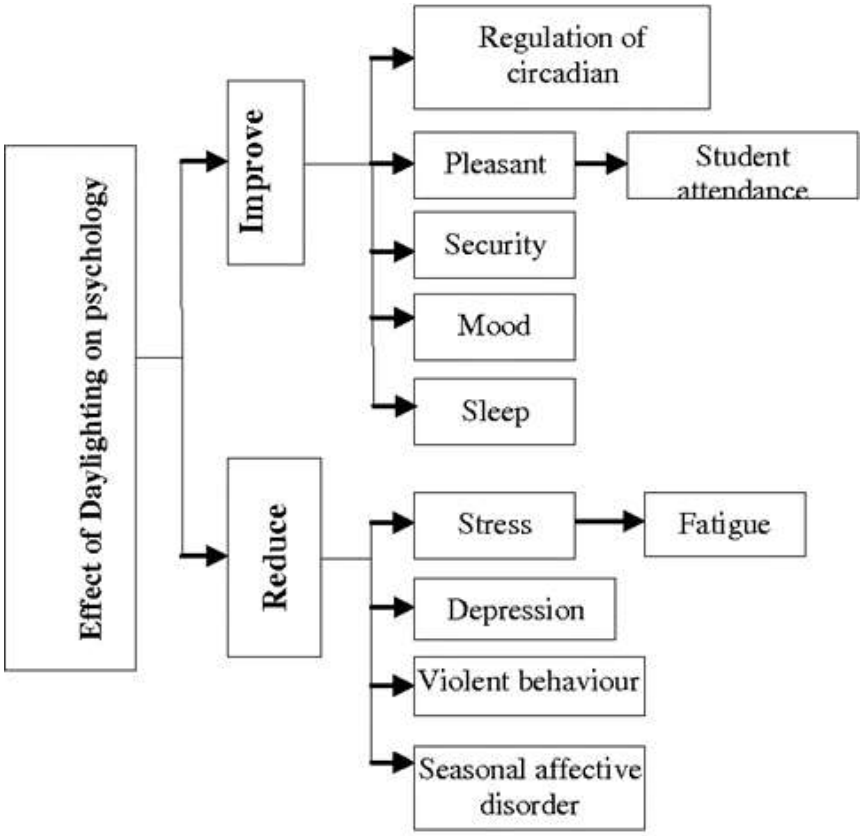

Figure 6 Effects of day light on psychology (source: Mirrahimi, S., Nik Ibrahim, N. and Surat, M., 2013)

The circadian system is the body's internal clock that sets a pace for all our bodily functions- banal or complex. It is also responsible for the timely regulation of body temperature. These researchers studied human subjects in a controlled environment experiment where they were subjected to absolute isolation with the absence of periodic environmental cues. Over a brief period, these persons had abnormal circadian rhythms and cycled at lengths greater than 24 hours. The results tally with the assertion that it is

the presence of vital environmental cues such as light that enable humans to synchronize their internal clock with the daylight (Figure 13).

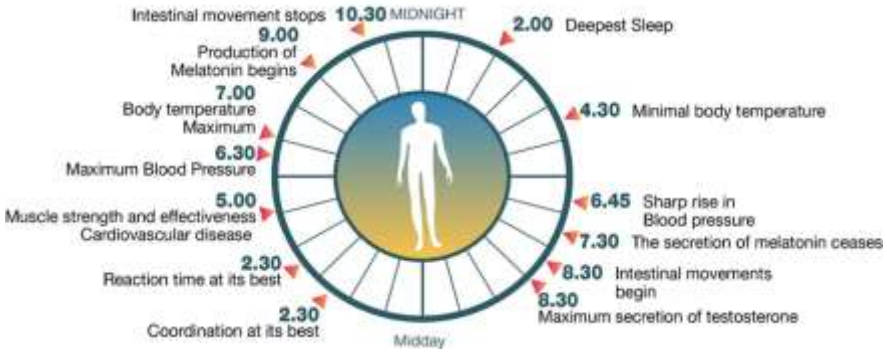

Figure 7 Figure 13 Activities by Internal Clock, www.staplesadvantage.co.uk

2.3.2 Daylight and student performance

In addition to its energy-saving properties, daylight in the classroom enhances the classroom environment, which is advantageous to students both in terms of health and learning outcomes (Sojoudi, 2014). The studies on the efficiency of illumination levels through daylighting in learning spaces demonstrate a significant impact on students' performance and behavior (Vi Le et al., 2016). According to the statistical analysis, the effects include improvements in student behavior and an increase in test scores (Heschong et al., 2002). In order to evaluate visual discomfort in learning environments, lighting aspects must be considered, including light efficiency for task performance, shadows, uniformity of light distribution, reflecting and glaring artificial lights (Boyce, et al., 2003). Indirect glare is caused by high levels of light intensity as well as bright colored surfaces, whereas reflected glare is caused by high levels of light reflection on walls, ceilings, and floors (Zumtobel, 2018). Reflected glare is caused by the intensity of the interior finish

colors, which can impact visual comfort (EFM, 2010). The lack of adequate lighting affects human physiology as well as students' learning abilities (Edwards and Torcellini, 2002). According to a study, 88% of existing classrooms evaluated received illumination levels exceeding those recommended in guidelines and standards. A further 84% of the classrooms evaluated exceeded the recommended illumination level, resulting in decreased visual comfort (Winterbottom and Wilkins, 2009). The mood, attention span, performance, and alertness of students can be improved in classroom with sufficient natural light (Shishegar & Boubekri, 2016). Additionally, students' sleep quality can be enhanced by implementing strategies that regulate their circadian rhythms (Short, et al., 2013). In order to enhance the quality of visual environment in a classroom, low glare and ample daylight sources can be combined with high-quality artificial lighting (Barret, et al., 2015).

As a result of healthy environments, studies have shown that students missed 1/3 fewer days due to illness resulting in 3.5 fewer days absent a year (Olson & Kellum, 2003). Another study details how due to inadequate lighting, students feel sleepier and unable to concentrate in the classroom. This leads to understanding that adequate lighting improves overall academic performance (Samani & Samanji, 2012). There must be considerations for sustainable design elements and strategies in green schools (Vi Le, et al., 2016). Sustainable schools that implement and operate sustainable strategies such as efficient daylighting can improve student performance (Ibrahim and Ahmad, 2013) in addition to the students' health (Demir & Konan, 2013). Additionally, teachers have also reported similar advantages to efficient day light in the classroom (Radwan & Issa, 2017). The effect of glare from high levels of daylight was studied by (Arabi et al, 2018) and found

that it can reduce students' eye acuity and reduce their performance which would have detrimental effects on students performance. According to (Figuero and Rea, 2010) eye fatigue due to visual discomfort is one of the factors leading to the loss of concentration (Ibrahim & Ahmad, 2013). Students' performance is reduced when they are not provided with the appropriate visual comfort for the required learning tasks (Gilavand, et al., 2016). Therefore, in order to facilitate specific learning tasks like reading and writing, adequate daylight should be provided in classrooms**.**

Lighting in classrooms appears to play a key role in pupils' learning. According to (Schneider, 2003) students and teachers tend to have distinct preferences for classroom lighting. Educators prefer natural light, according to (Hathaway, 1983). whereas (Lang, 2002) reported that teachers prefer to set the lighting themselves. In smaller scale studies, lighting and achievement have also been linked. According to (Hathaway, 1994) the use of fluorescent lighting is associated with higher educational achievement. (Heschong and Knecht, 2002) evaluated a large sample to determine whether there was a significant correlation between achievement, and both (1) the amount of daylight that the teacher had control over and (2) the amount of diffuse daylight in the classroom. Furthermore, numerous studies have found that certain lighting regimes result in changes in behavior. It was discovered by (Fenton and Penney,1985) that children with autism exhibit repetitive behaviors more frequently when exposed to fluorescent lighting; (Schreiber, 1996) reported that when light levels were reduced, children became more relaxed and engaged in lessons while (Shapiro, Roth, and Marcus, 2001) observed that maladaptive behavior of children decreased when indirect diffuse fluorescent lighting was used. Research by (Treichel, 1974) also proposed that fluorescent lighting exacerbated children's

hyperactivity. Additionally, other researchers have considered the effect of environmental factors such as lighting on the learning process. (Dyck, 2002) suggested that aspects of lighting are necessary to establish a state of 'flow'. According to (Lyons, 2002), fluorescent lighting with full spectrum allows students to retain and learn information in a more productive manner while (Rittner and Robbin, 2002) noted the positive effects of daylight on retention and teaching. There has also been research by (Schulz, 1977) highlighting the need to avoid excessive lighting. Overall, while the importance of daylight is emphasized by some authors, it is generally accepted that day and artificial light need to be integrated (Woolner, Hall, Higgins, McCaughey, & Wall, 2007).

2.4 Color Rendering Index

Color Rendering is a measure of the tendency of a light source to intensify the color of an object by reflection to the human eyes (Table 1). The Color Rendering Index (CRI) measures the way that colors look under various types of light and is generally measured between zero to hundred. On the scale, zero would enable us to view colors to appearing the same, while hundred would show all the different colors of the object. Lights have different CRI, and it can range from anywhere between twenty and eighty for most lights. A light source is considered to be optimal if its CRI is between eighty and ninety as a high CRI shows that the light source has an excellent color rendering ability. Old fluorescent lights have a CRI of seventy while the new fluorescent light source has a CRI of ninety.

The lighting of the classroom will improve if LED lamps (mostly with CRI of ninety and hundred) are put in a class as LED lamps have a color rendering index of more than ninety, which is above average because they are close to 100 CRI which is the value of sunlight.

According to (Hathaway, 1995) sunlight is noted as the reference point for the CRI, and it has an index of 100. The sunlight is 100 CRI as it combines all the colors (red, orange, yellow, green, blue, indigo and violet) in the spectrum, and the intensity of the color of the object when sunlight reflects off it just shows the true intensity of the color of the object. Sunlight is often used as a reference for lights with cool color temperature, while an incandescent light serves as a reference point for lights with "warm" color temperature.

Find in table 1, the average color rendering index ratings for a variety of lights:

CRI	DESCRIPTION
22	High Pressure Sodium Lighting
62	Common 4 foot Fluorescent Tube
80 - 85	Compact Fluorescent Lighting (Warm White)
85	Premium 4 foot Fluorescent Tube
80 - 90	Solid State LED Lighting
95	Incandescent Light Bulb

Table 1- Color Rendering Index Source: www.eprints.uthm.edu.my/3657/1/mohd_hafiez_ahmad_1.pdf

2.5 Visual discomfort factors

2.5.1 Intrinsically Photosensitive Retinal Ganglion Cells (ipRGCs)

Intrinsically Photosensitive Retinal Ganglion Cells (ipRGCs) Figure, 14 play a significant role in the stimulation of non-image forming effects and are regarded as the third class of photoreceptors found in the retina. The ipRGCs were discovered in 1923 when mice responded to light simulation despite not having cones and rods which are the two known light-sensitive neurons or photoreceptors. The response of the ipRGCs may appear slow but it is more consistent and can detect light over a longer period compared to cones and rods.

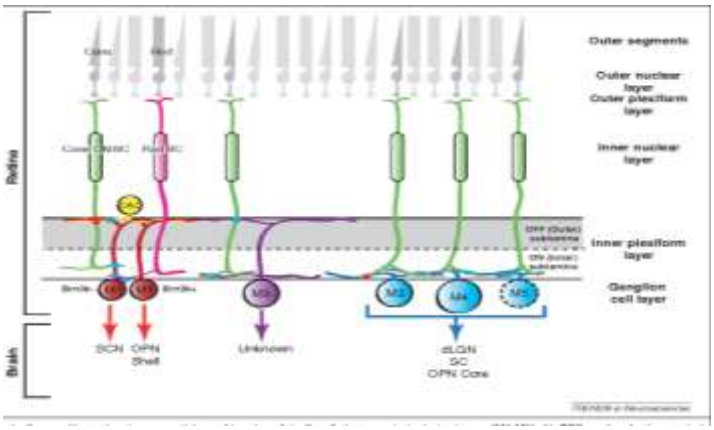

Figure 8 Intrinsically Photosensitive Retinal Ganglion Cells Source: www.cell.com

There are several species that are diurnal, including humans, that have developed complex mechanisms to regulate physical processes based on time of day. In other words, it is produced due to the circadian rhythms that are involved in the natural cycle of light and dark that lasts 24 hours a day. It is known that the master body clock in the brain is of great importance for controlling the human circadian system. This master body clock, or circadian clock, can be found in the hypothalamus of the brain's suprachiasmatic nuclei (Czeisler, 2013), which controls metabolic processes, hormone secretion, body temperature, cardiovascular function, and aging processes (Anna and Roman Kondratove, 2012).

Light is believed to have harmful effects on the health of the general population by affecting the production of melatonin. In addition to its immune functions, melatonin is also found to protect against various types of cancer, including breast cancer (Blask, Brainard, Dauchy, Hanifin and Davidson, 2005). Several researchers have found decreased levels of melatonin at night correlate with decreased cancer-suppressive properties (Fronken and Nelson, 2014). Nevertheless, other studies have not found a similar

correlation, perhaps because of various confounding factors such as the diet and lifestyle of individuals in the studies (Kalsbeek, Merrow, Roenneberg and Foster, 2012).

2.5.2 Flicker and Glare

It is inevitable that the output of light or the range of its spectral power will change rapidly and repeatedly during the lifetime of an AC-powered light source. It is due to these fluctuations that a phenomenon known as temporal light artefacts (TLAs) appears, as well as flickering, strobe effects and phantom array effects. Specifically, (Veitch, Martinsons, Coyne and Dam-Hansen, 2021) explain that flicker and stroboscopic effects are the result of observers in a static environment. Flickering occurs when observers in a non-static environment change the perception of moving objects, while the phantom array effect occurs when non-static observers are present in a static environment, which causes changes to perceived shapes and spatial positions of objects.

Flickering light is the most widely known type of TLA, and it is an essential part of indoor lighting systems. This effect has a significant impact on our visual system, especially when it is present in large amounts. (Boyce,2014) states that there are three factors that are deemed relevant for determining whether flicker is visible or not to the eye: the frequency and percentage of the modulation, the field of vision over which the flicker occurs, and the luminance of the light source. In accordance with the work of the Commission Internationale de l'Éclairage (CIE), flicker is considered a visual perception effect. There have been many studies that have looked at flicker as a behavioral phenomenon, but it has also been investigated as a health hazard at fluctuation frequencies above the threshold at which it is still perceived by human eyes (Veitch, Martinsons,

Coyne, and Dam-Hansen, 2021). Studies have shown that the critical flicker frequency is able to reach 90 Hz in biological systems.90–94 Below this threshold, individuals without a history of epilepsy or any other symptoms representing neurological disorders may develop symptoms such as malaise, fatigue, eyestrain, headaches, as well as seizures (Wilkins, Veitch, and Lehman, 2010). On the other hand, there can also be adverse impact from flickering at a frequency that exceeds the critical threshold.

According to (Wilkins, Veitch, and Lehman, 2010) the human retina is capable of detecting flicker in the range of 100-200 Hz. There are a number of sensory and neural responses that are triggered by this, resulting in mental and physiological stress, visual disturbances, eye strain, excessive eye movements, loss of visual function, headaches, and fatigue (Jean, Sandoval, Kolombo, and Troscianko, 2013). Despite good vision and healthy visual health, people can still be adversely affected by flickering above the critical flicker frequency. Flicker sensitivity does however differ from person to person, such as those who are prone to migraines, individuals with autism, or those who suffer from photosensitive epilepsy. It can also lead to problems when reading or performing tasks on a computer screen (Perrin, Brown, Poplawski and Miller, 2016).

Human eyes are capable of adapting to a wide range of luminance over the course of their lifetime, but comfortable vision occurs only within a limited range at any one time. A high luminance or luminance contrast in the visual field may cause glare. The society of light and lighting posit that there are two types of glare that are commonly encountered in indoor environments; disability glare and discomfort glare (UK:SLL , 2012). (Vos, 2003) describes how the light emitted from very bright sources is scattered primarily in the cornea and lens, causing stray light to be reflected back to the retina, causing less

contrast in the retinal image, as well as a reduction in visibility (Berg, Rijn, Michael, Heine, and Franssen, 2007). This results in disability glare, which causes impaired or, to a degree, even temporary blindness. Despite the fact that disability glare poses no direct health risks, it may pose indirect safety risks by impairing sight and recognition capabilities (Ticleanu, King, Howlett, Sener, Aarts and Van Duinhoven, 2015). In fact, (Boyce, 2014) state that straylight and disability glare are associated with increased age, even in eyes that are considered healthy (Berg, Rijn, Michael, Heine and Franssen, 2007). According to (Evan and Jessa, 2009) people who suffer from cataracts will experience their symptoms to an even greater extent. A general observation is that sunlight generally constitutes the most common source of glare in a home environment. A general consensus has been reached that discomfort glare refers to the perception of an unpleasant contrast between luminance and contrast in the visual field. An individual with this condition experiences visual discomfort without necessarily affecting their vision. A number of studies have shown that discomfort glare can be caused by changes in pupil sizes (Lin, Fotios, Wei, Liu, Guo, and Sun, 2015) as well as cramping in the muscles surrounding the eye. According to (Murray, Plainis, and Carden, 2002), the pupil, lens, and extraocular muscles are constantly adjusted in order to maintain a clear retinal image. Muscle tension and discomfort can result from this constant muscle adjustment.

(Stone, 2009) notes that glare discomfort may manifest as annoyance, irritability, distraction and visual fatigue. In addition to sore eyes, dry or watery eyes, itching, blurred or double vision, difficulty focusing, irritation of the eyes and lids, muscles tension, and headaches, this condition is also associated with other conditions such as neck- and back pain. The presence of discomfort glare has also been associated with adverse effects on

mood and wellbeing (Howarth, Heron, Greenhouse, Bailey, and Berman, 1993), (Mork, Falkenberg, Fostervold, and Thorud, 2020). Furthermore, there exists differences in sensitivity to discomfort glare (Ashdown, 2005) among individuals within the same space. (Stone, 2009) notes that glare lighting may not be an issue for some people but may be problematic for others in the same room. (Boyce, 2010) indicates that migraine sufferers are more likely to experience glare or are unable to tolerate bright light even when they do not suffer from a headache. According to (Bullough, 2009) the spectral power distribution of the light incident at the eyes does not appear to matter significantly for disability glare, but it may affect ratings of discomfort glare from sources that emit more short-wavelength light. In this regard, blue-emitting sources of light, for example cool white lamps, are likely to generate significantly more glare even when the amount of light reaching our eyes is the same. Light scattering increases with age, therefore older individuals may be more sensitive to it.

2.5.3 Other health risks due to lighting

Light exposure can cause eye damage, apart from causing glare in some cases, depending on the amount of time spent in direct sunlight and the luminance, angular shape, and spectrum of the light source (Ticleanu, King, Howlett, Sener, Aarts and Van Duinhoven, 2015). Photokeratitis and photoconjunctivitis (damage to the cornea and conjunctiva) can resul in irritation, light sensitivity, or even severe pain; cataracts (damage to the lens) result in opacity, light scattering, and less light reaching the retina. The retina can be damaged by photoretinitis and retinal burns (damage to the retina) or the fovea of

the retina can be damaged, resulting in loss of central vision (Ticleanu, King, Howlett, Sener, Aarts and Van Duinhoven, 2015).

Infants and children normally have highly transparent lenses, whereby they are much more susceptible to retinal damage. A person with age-related macular degeneration, as well as someone who has had their lenses removed or replaced, are also more prone to retinal damage (Boyce, 2010).

As a result of its higher energy and shorter wavelength, short-wavelength radiation such as blue light is more harmful, which is why it is often referred to as blue light hazard (Bullough and Mies, 2000). Blue LEDs and phosphor coatings are common ingredients in white LED light sources, so they produce peak emissions in the blue range of the spectrum. Other lamp types with similar correlation colour temperatures (CCTs) emit comparable amounts of energy in the blue region. On the other hand, the blue light hazard is determined by spectrally weighted irradiance on the retina and exposure duration, which, in turn, is determined by the size, radiance and viewing conditions of the source (BSI, 2008). It appears that the spectrally weighted radiance of the light source is fundamental in determining blue light hazard. An evaluation of several types of light sources found that 119 white LED light sources (rated 3000 K, 4000 K, and 6500 K) exhibited no blue light hazard over incandescent lamps. This difference is likely due to the higher luminance of an incandescent lamp's filaments. Although pure blue LEDs were found to be significantly more hazardous than direct sunlight, the risk still nonetheless remains lower than that posed by the sun's rays. It would be necessary to limit the exposure time to such high-risk light sources in order to reduce potential health risks.

Skin damage can also be caused by radiation. When the skin temperature is sufficiently raised by visible and infrared radiation under very high radiation levels, burns can result (Boyce, 2014). There is no risk of skin burns from the usual lighting sources, as the levels of radiation are far below the threshold for thermal injury, however burns can result if one touches a hot lamp or luminaire (Ticleanu, King, Howlett, Sener, Aarts and Van Duinhoven, 2015). UV radiation can also cause skin damage such as erythema (sunburn), elastosis (photoaging), and cancers, yet these damage types mainly occur outdoors since indoor levels of ultraviolet radiation are very low (Ticleanu, King, Howlett, Sener, Aarts and Van Duinhoven, 2015). It is important to note that the ultraviolet radiation emitted by fluorescent light sources may cause skin damage. Overall, LEDs produce few or no ultraviolet emissions (Bullough, Bierman and Rea 2019), and most indoor lighting does not pose a risk. Some people with certain skin diseases such as chronic actinic dermatitis they may be highly sensitive to wavelengths (Eadie, Ferguson, and Moseley, 2009) and it is recommended that individuals with such conditions avoid UV radiation emitted from unscreened lamps. (Henshaw and O'Carroll, 2008) report that electrical currents can be induced in the human body when electromagnetic fields are above a certain intensity. Electrical currents at low frequencies can stimulate nerves and muscles while electrical currents at high frequencies can heat tissues. The electromagnetic fields can cause some people to experience dermatological symptoms including reddening, tingling, burning, but also headaches, fatigue, dizziness, nausea, and difficulty concentrating (Henshaw and O'Carroll, 2008). Although technological advancements have contributed to a reduction in electromagnetic fields generated by lighting products, there is still a long way to go before they are completely eliminated. Based on the results of (IEC, 2013) and

(Nadakuduti, Douglas, Capstick, Kuhn, Benkler and Kuster, 2010), it can be concluded that the Typical light sources, such as fluorescent and LED lamps, generate electromagnetic fields that are considerably below the limits that are recommended by the International Commission for Nonionizing Radiation Protection as found in (ICNIRP Guidelines, 2013). In summary, an overview of both improving and harmful effects of daylighting on health can be found in Figure 15.

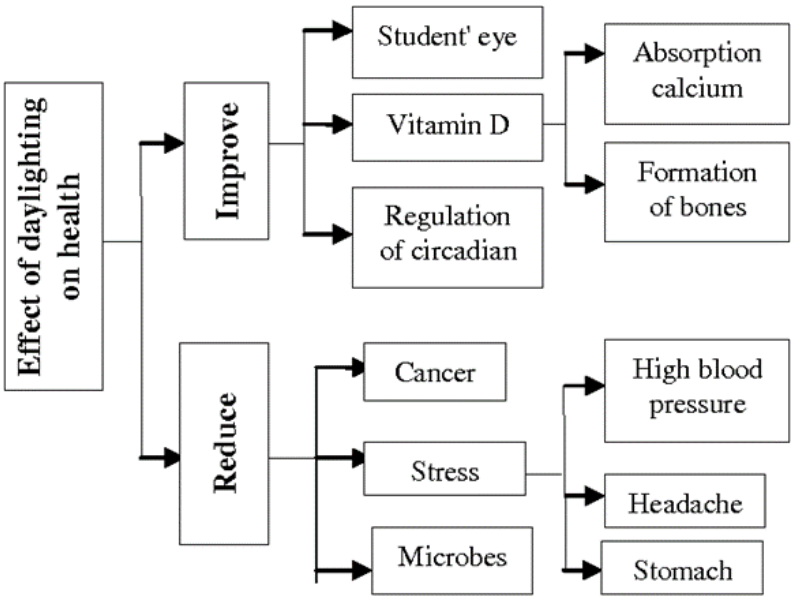

Figure 9 Effect of daylighting on overall health

2.6 Research Question

This study will establish a research plan that will investigate the effects of different types of lighting on occupants' performance in the classroom and aim to identify the type of lighting that will enhance learning and teaching conditions in the classroom. Using a range of light sources in different classrooms can demonstrate the impacts of the different types of lighting in classrooms by taking into account all other variables that may influence the outcomes of the study. Several factors will be considered in the design of this study, such as lighting, the use of

the space, tasks that are performed and the interior setting. Through the use of appropriate techniques and methodologies, we aim to providing a sufficient answer to the research question.

In specific, the research question will have the aim of studying how the lighting in schools in the United Arab Emirates affects the health and performance of students. Taking into consideration that the experiment will last an entire academic year, it might be reasonable to expect the results to be accurate since a significant amount of time will have passed to exhibit potentially beneficial effects on the children. Earlier, similar experiments were carried out over the course of one day, which was insufficient time for a significant impact to be demonstrated. In order to maintain a consistent and healthy environment for children, no other major changes will be made to their classroom and schedule. Therefore, the purpose of this experiment is to establish the effects of different color lighting on the productivity of users, in order to demonstrate how lighting influences work performance thereby suggesting a lighting scheme that will lead to less pollution, better productivity and one that is environmentally friendly. The result would be to have a comprehensive response to the question, in addition to generating suggestions regarding future research, investigations, and experiments.

2.7 Dissertation Hypothesis

Artificial lighting influences human health, but it is not clear to what extent. Considering that the effects of light are both physical and psychological, the present study investigates the effects of different lighting fluorescent, full spectrum fluorescent and LED that might be effective in reducing pollution, improving user performance, and being environmentally friendly. Two classes of ELC students from the Early Learning Centre ELC will be observed and tested as part of the monitoring process.

Researchers have found that lighting interventions in the built environment can influence human behavior and performance to a significant degree. Although it is still unknown what long-term effects dynamic and tunable lighting will have on the quality of focus and concentration, research by (Mott, et al., 2012) and (Sleegers, et al. 2012) supports the theory that high Kelvin lamps may have a positive effect on focus and concentration. There has been evidence to demonstrate positive effects of high correlated color temperature (CCT) on cognitive performance and on-task/off-task behaviors in laboratory studies conducted by (Grangaard, 1995), (Knez, 1995), (Smolders and de Kort, 2016), as well as (Hawes, et al, 2011). Based on the results of an experiment conducted by (Hayes et al. 2011), LED lamps with higher CCT were found to be more effective at increasing perceptions of performance and arousal states than fluorescent lamps. It's hypothesized that LED lamps with a higher Kelvin temperature are more efficient at producing light. A higher Kelvin temperature is expected to positively influence students' behavior, actions, and attitudes.

However, it is important to note that controlling certain variables in the classroom may be difficult and inadvertently affect the results, potentially leading to different conclusions. It would be beneficial to use the field monitoring approach in dealing with such topics in order to obtain more valuable and trustworthy evidence. The purpose of this study is to raise awareness of the need for classroom design, especially in elementary schools in the United Arab Emirates, which has been requested by the committee responsible for classroom design. As the goal of this study is to greatly enhance understanding of what we know to be the most effective, efficient and environmentally friendly lighting that is compatible with the light that is generated by daylight during the daytime. This study aims to demonstrate how essential it

is to pay attention to details of lighting design when dealing with the additional variations and atmospheric conditions prevalent in the UAE throughout the year.

3 CHAPTER 3

METHODOLOGY

3.1 Similar studies - different methods

There has been a growing number of research studies conducted on the biological, health, and behavioral impacts of lighting since the mid-1990s. The consequent rapid development in lighting research has prompted the following review to be focused on the main issues and requirements that need to be addressed as well as potential ways in which they may be translated into practical application (Veitch, 2005). The purpose of this section is to compare the various research methods used in a number of studies and research papers in order to illustrate how relevant they are to this dissertation topic and the variance in the types of settings and conclusions.

3.1.1 An Overview of the Theory

As a result of a significant increase in research exploring the impact of lighting on behavior, satisfaction, mood, and performance (Boyce, 2004), many researchers now have their attention focused on lighting. As part of its efforts to better understand biological and psychological processes involved with lighting, the lighting industry has adopted a number of scientific reviews. The detailed explanation given by (Boyce, 2004) with regards to the process of developing a relationship between the effects of light on psychological and biological effects will prove to be helpful to further research in this area. As a result of these studies, we have demonstrated that light contributes to biopsychological processes, with a potential for further application for advanced research in the near future (Veitch, 2001).

Future research may want to explore several important aspects that are identified and highlighted in reviews. As a result of such reviews we benefit from avoiding studying research topics which may waste time and resources. There is no doubt that reviews of the type described here are informative, clear, and help to decide how future research should proceed (Veitch, 2005). There is still much to be explored in the area where light affects mood, behavior, health, and productivity (Boyce, 2004). A comprehensive understanding will help determine the appropriate lighting design for biopsychological processes, but without a clear understanding of these processes, it will be difficult to do so. It is essential for future lighting research that a comprehensive and informative review is conducted in order to understand the type of hypothesis developed. Researchers from the fields of biology, psychology, and lighting suggested that the scope of research on the impact of lighting on health and well-being should be increased. As a result of the importance of the need for these advanced studies, in order to be able to develop an understanding of visibility, whether in terms of its positive or negative aspects, this review can prove very helpful to both researchers and potential users in deciding which research method is most suitable to address any of the obvious topics (Veitch, 2001).

With regards to this study, we determined how different the LED and full-spectrum lighting is from fluorescent lighting and how it affects the learning process in classrooms by comparing it with the effects of adequate daylight. To achieve the aim of this study, the behavior of the pupils who formed the sample population were diligently observed over six weeks in the classroom.

3.1.2 Sociological Survey

A study by (Tonello, 2004) explored the effects that lighting (natural and artificial) and interior decoration have on workers' moods and productivity. However, A series of emotional results indicate that the interior environment (lighting and décor) has a significant influence on workers' moods, especially in the darker seasons (Tonello, 2004). From a psychological perspective, it was shown that the workplace environment and lighting were more important in explaining the moods of workers than the effects of the season. It explored how light and mood can be connected in a subtle way as well. Generally, good lighting can improve occupant's emotional mood as well as improving their ability to cope with stressful situations (Tonello, 2004).

Based on the specific target population, it was determined that a survey manually filled would be used for data collection. This method is the most inexpensive of all the survey methods, and it is also the quickest to achieve (O'Neill, 2000). Secondly, the answers given by the participants are direct, therefore providing data that is not as limited. A social survey was used as the method for carrying out the study, which allows for the researcher to be able to control many of the parameters of the study, in the way that many of the parameters have been set in the questionnaire so that they will be consistent with the hypothesis. Consequently, an extensive database of answers could be developed (Tonello, 2004). However, It is likely that there will be a number of issues that will cause difficulties. Participants may interpret the questions incorrectly, which can lead to incorrect or biased responses, which is one of the most significant challenges we have to deal with.

The data was analyzed using descriptive and inferential statistics as a result of an elaborate survey study. (Howell, 2002) Analyzes descriptively and inferentially as a reliable statistical procedure. Statistical inferences were drawn and applied to the descriptive and inferential data to critically examine the metrics between lighting and student attendance, performance, and achievements. This goal would be achieved by examining two groups of children in rooms with full-spectrum and fluorescent Lightings. The statistics gathered from the analyses included frequencies, regressions, means, and standard deviations, and the findings from the study are depicted using tables and graphs.

3.1.3 Simulation

The ability to create a virtual study is rapidly becoming one of the most popular means of saving time and money by conducting a simulation. A virtual study has been created towards a better understanding of the model to be followed. By applying the proposed model to real interiors as a result of such simulations, it may be possible to examine the impact of light in real interiors as a result of the simulations.

A classroom is one of the most challenging environments to apply effective lighting, which is the main focus of this study. Initial evaluations of luminance and illuminances were conducted in existing schools. We took into account to identify the tasks students and teachers perform in the classroom. The following is a description of the lighting design for classrooms (artificial lighting) that is designed to ensure that students and teachers in the classroom are comfortable and that their performance is improved by combining high-quality daylight and artificial light in a planned manner (simulating results).

3.1.4 Observational

A number of studies examine current interiors and lighting (daylight and artificial) to determine how the lighting affects Performance and mood of users. An investigation conducted by (Heschong et al, 2002). found a link between human performance and daylight. The study examined three school sectors with various educational programs, management and teaching methods, weather conditions, and building designs with several variables set for each of the sectors. This included the age of the school, the size of the classroom, the number of windows and skylights, and the type of classroom. An analysis of the collected data was conducted to assess the importance and influence of each variable simultaneously. This study found a strong connection between daylight and students' performance, which has the potential to be carried out in other settings, such as offices and workplaces (Heschong et al, 2002).

(Figueiro et al., 2002) conduct a study during the winter of 2001 to compare worker behavior between offices that were equipped with windows and those that were not. The purpose of the study was to determine whether it was the lack of daylight (winter timing) that affected productivity. In a recent study, researchers found that workers with windowed offices spent more time focused on their work tasks. In addition, they were less likely to waste time on phone calls or chatting with colleagues than workers with interior offices. The results of this study are not discussed in detail but appear to clearly show that bright daylight during the daytime can lead to greater productivity during the winter months.

With regards to this observational study, the objective was to determine whether winter affects workers' productivity in two types of offices (offices with windows and

offices with doors). Based on these results, it can be concluded that workers in windowed offices were more productive than those in interior offices. Although this study did not examine the relationship between circadian rhythms and performance, it was concluded that during the winter months, daylight may have an adverse effect on the productivity of employees at work. In the conclusion of the study, further research is recommended into the relationships between daylight (bright light) and productivity (Figueiro et al, 2002).

3.1.5 Experimental

Experimental methods are the most robust and highly effective method of conducting a research study. Although there is a large amount of time and money involved, the outcomes can be easily verifiable or easily rejected in real life. Experimental results may lead to further research or identify improved solutions.

One hundred and eighteen participants participated in a one-day laboratory experiment in which the light source was chosen from four designs. The light was not controlled while during the second half of the afternoon, each contributor was given individual control (dimming). Additionally, the contributors were required to complete questionnaires that covered a wide range of topics including mood, contentment, and distress., and distress. According to the results of the questionnaire, lighting control had a positive influence on mood, vision, performance, productivity, vision and environmental quality. Those who contributed exerted considerable control over the lights had the greatest impact on their results. In contrast, those who only slightly adjusted their lighting did not experience a significant improvement in their results. It is therefore likely that the performance was affected by the way the controlled lighting was applied, rather than the

control itself. Further study is recommended regarding these results (Newsham et al, 2004) as results regarding task performance was unclear. However, there did appear to be a correlation between providing individuals with controlled lighting and their performance on tasks. Virtual tasks would have affected the outcomes, but the questionnaire was able to add some realism to the tasks. This experiment was intended to last one day and be extended if positive results were obtained (Newsham et al, 2004). To study the effect of illumination on occupant's performance and health, two field simulation experiments have been conducted. In the first experiment, four types of lighting were used: (1) direct light, (2) indirect light, and (3) mixed light, as well as (4) desk lamps that can be controlled individually and (4) workstation light. A total of two types of lighting were used in the second experiment, neither of which can be controlled: (1) direct lighting and (2) (direct and indirect) lighting. According to the study, such lighting were not impactful on the performance of the workers, even though the Controllable lighting was found to be beneficial in the study and may increase motivation and performance (Boyce et al., 2006).

It was reported by (Boyce et al, 2006) that lighting adjustments affect human performance, mood, and health statistically. However, the study concluded that there was not a significant effect. According to (Veitch et al, 2008) the connected instruments that are tested in these two experiments have been shown to influence health, mood, and task performance. Researchers concluded that employees who identified high-quality lighting in their workplaces exhibited improved mood and health by the end of the workday. A significant finding was that direct and indirect lighting was preferred by workers, and those lighting situations that improved visibility also enhanced task performance (Veitch et al,

2008). Another one-day laboratory experiment was set up by (Newsham et al, 2008) to investigate the effect of individual lighting control in a day-lit office. The office laboratory, which had no glare and was well-lit, was used by forty participants, each of whom was given 30 minutes to adjust the electrical lighting to their liking. The lighting readings were recorded before and after each adjustment, and luminance maps were created by utilizing a professional and advanced digital camera. A significant difference was found between the existing illuminance of the desktop and participant-adjustments in lighting. According to the participant's point of view, natural lighting is needed and may replace artificial lighting (Newham et al, 2008). In 2008, Researchers Newham and colleagues present new techniques for obtaining new findings in the lighting research field in this study, as previous studies have proposed various methodologies and aspects to be explored (Boyce 2004). Even though the experiment was limited in time, it was able to demonstrate most of the hypothesis, which should be motivation for further research on the hypothesis. According to the experiments, automatic lighting controls did not effectively satisfy the needs of workers, and the energy output was reduced by 25% based on the adjustments made by participants (Newsham et al., 2008).

In this experiment, three different classes at Victoria International School (VISS) in The Early Learning Center (ELC) in Sharjah, United Arab Emirates, are referred to as Classroom-A, Classroom-B and Classroom-C. This experiment took place in Early Learning Centre classrooms at the Victoria International School in Sharjah, UAE during the academic year 2021-2022, which is following the Australian curriculum. By comparing the effects of adequate daylight with those associated with full-spectrum,

fluorescent and LED lighting, this chapter presents descriptions and explanations of the findings as guided by the research questions of the study. It critically examines the effects of full-spectrum, fluorescent and LED lighting on the process of learning in classrooms by comparing them with those associated with adequate daylight.

An academic year at Victoria International Private School is divided into three semesters, which start in September and end in June. These three semesters conclude at the end of December, March, and June respectively. Students are provided with grade reports at the end of each semester following the conclusion of the evaluation process. Using key performance indicators as metrics, the results of the analyses were used to measure the effectiveness and efficiency of the school. Based on a comprehensive review of online and offline sources, the key performance indicators have been developed. Based on the analysis, key performance indicators were used to evaluate the efficiency and effectiveness of the school. As a result of the study, a correlation between lighting and student performance will be determined and it is hoped that the findings will provide further insight into the decade-old question of unknown environmental influences. The school administration will be provided with guidance on how to best channel school resources towards improving students' visual comfort.

Furthermore, the findings of this study will be useful to future research students who wish to perform further studies on the same topic. It will enhance the researcher's knowledge of the impact of lighting on students in classrooms. Despite the fact that the number of students attending schools is on the rise and there is no visible change in the

physical environment, it is imperative that these schools improve the academic performance of their students.

(Juslin & Tenner, 2007) designed a study with the purpose of examining variable conditions of lighting in one area (dimmable task lighting ,skylights and daylights). A luminary factory was being built in France, there are six work sites with dimmable task lighting that are illuminated by a skylight, available at any time for workers to use. After the experiment was completed, the participants completed a questionnaire form in which they reported their readings from winter 2004 to spring 2005. When light levels change (more or less) and task performance changes, task lighting was used. Users indicated that task lighting improved their performance and that they preferred for this system to remain in place (Juslin & Tenner, 2007). In the study, it was found that task lighting was not required very often in a daylight-lit work environment (except for when the daylight intensity changes). On the other hand, it concluded There is a strong indication that the task determines the lighting time and option, since almost all of the workers used the task lighting and many pointed out that it improved their performance. In light of these findings, skylights should be used in workspaces (Juslẻn and Tenner, 2007).

3.2 Research Method of the Study

The aim of this study is to assess and measure how individuals perform under different types of light based on their performance. Comparing the experimental research method to the other research methods discussed previously, we considered experimental analyses with simulation are the appropriate method for studying this topic. Other methods mentioned would not allow for as much experimental control and this was of value to the researchers. The purpose

of an experiment is to provide the audience with a more accurate and objective understanding underlining clear cause and effect while providing objectivity and accuracy when assessing the dependent variables. Moreover, there was no sampling bias in the field experiments and there was no bias in analyzing the characteristics of the demand (Colorado State University, 2008).

It is concluded from these experiments that the most effective approach would be to conduct in primary and elementary school in the UAE to determine what changes in tasks, performance, moods, and health are caused by changes in lighting. It is expected that the variables to be considered include artificial lighting (fluorescent, full spectrum and LED lighting), student's results, questionnaires, and classroom design. Due to the many different methodologies that have been used in research on the effects of circadian light on the human eye in the past, the experimenters found that computer simulation was the most advantageous method for conducting this research. Using a variety of luminaire types with varying beam distributions and multiple CCTs, this study examined the effect of these luminaires on the circadian rhythms of the human body. Since the variables in this study are subject to a wide range of variations, computer simulations are the most suitable method with the advantage of the ability to control several variables. This is particularly important as there will be approximately 40 luminaires that will be tested through the course of the study. As a result of the use of computer simulations, the possible errors that can arise from human or instrument error can be reduced to a minimum, providing more accurate and reliable results **.** moreover experiments in site are having important results with reality which future researchers can use.

3.2.1 The Methodology Framework

The purpose of this study is to determine whether the type of lighting in a classroom affects the performance of students and teachers. In order to improve the learning environment in the classroom, a study will be conducted to determine what type of lighting might be effective. In addition, the study will take into consideration the impact that various lighting settings may have on learning in different classrooms. In addition, it will also consider other factors that may influence the results. In the experiment, a number of predetermined variables are addressed, including: the lighting, both natural and artificial (warm and cool, fluorescent and LED), teachers' and students' use of the space, significant work areas (boards, desks, student workstations, activity rooms), elements of the interior environment (furniture, color, materials, finishes), teacher's tasks (writing on a blackboard or whiteboard, reading from a whiteboard, talking to students, reviewing student work, preparing lesson materials and presentations), and student tasks (writing on whiteboards, reading from whiteboards) using their laptops or ipads and class work (writing, reading, drawing, paying attention to others, etc.).

It is anticipated that the study of these factors using the appropriate techniques and methodologies will provide us with additional research questions to be investigated in future research for the benefit of the learning and teaching environments in classrooms, as well as to answer this thesis' research question: which type of lighting might be beneficial to improve the learning and teaching environments in classrooms?

3.2.2 Duration of the study

It is commonly believed that longer exposure times have the effect of making the results more apparent. There are several experiments that have shown a direct relationship between performance and lighting over a particular period of one day, while others have shown a greater correlation over the course of several months. While in regards to this study the lights have been placed in the classrooms before the start of the first term in September and then in march the questioners to the students were given.

3.2.3 Geographic location of the study

The study will take place in international school in the United Arab Emirates. Specifically, the Cycle One year group was selected, as forty percent of the total student population of Dubai schools is enrolled in Cycle 1. There are several reasons for this decision, including: the diversity of the users (teaching staff and students), interactive nature of the classroom; lengthy working days, allowing the teacher to observe students. Student evaluation was also common practice in the classroom which was an added benefit. There are several different types of schools in UAE, allowing us to find similar environments used by different users which can be compared across the board. Additionally, different types of light effects mentioned in other studies can also be compared along with previous evaluations as appropriate.

3.2.4 An overview of the study's environment

It is recommended that three classrooms with the Australian curriculum are used for comparison. In order to maintain the expected results under different lighting conditions, it is necessary to vary the interior design and color scheme in order to ensure that the interior design and color scheme do not interfere with the results. According to the

analysis, there may be some minor changes that need to be made. During the duration of the experiment the students will be able to sit in designated areas for consistency purposes (as this will affect the results since it is a variable that will be recorded). There are rotations of classrooms every semester (sometimes more than one classroom is rotated at once).

3.2.5 Lighting

It is always important to take into account the lighting when conducting rotations in a classroom. Lighting specifications, whether direct or indirect (fixture designs, types, or any other type of lighting) will be recorded as needed. During every rotation, natural lighting will be utilized as the main source of illumination, while artificial lighting will be variable and changeable as needed on a rotational basis (if it is possible).

3.2.6 Data collection methods

We used a variety of methods to evaluate this project, including simulation, observations (walkthroughs and photographs, observations, comments, etc.), site analysis, interviews (with teachers, students, principals, supervisors, etc.), and evaluations of student grades, questionnaires, illumination measurement, and behavioral analysis.

3.2.7 Observing the Environment

During the preliminary conversation, teachers will be directly asked about the environment and its impacts. As part of the new system, a system for monitoring lighting reports will also be established (for maintenance, life, problems, and technical issues). On the grounds of Victoria int'l school, a survey was administered on a Monday morning. Some parent assistants were briefed and trained on the purpose of the survey. Upon arrival, the participants were welcomed and brief explanations of the survey as well as its purpose were given, ensuring children that their answers can't be incorrect. Participants in the

program aged four to six had access to parent assistants who were available to assist and provide answers to questions. Specifically, the survey was designed to have a maximum of eighteen questions, taking into account the attention span of participants of different ages; and it was conducted in a low-stress, non-school setting so that participants would not feel anxious. Participants took the survey using iPads and laptop computers. The survey was completed by all 52 participants within the three-hour program.

3.2.8 Students' Grades and Data

Children in the United Arab Emirates are enrolled in the first cycle of primary education (grades two and three, Cycle One). The quality of education and health of the children are directly linked to their attendance. Due to this, it is important to improve their interior environment in order to be able to focus on them. As a result of their sensitivity to their surroundings, we can easily see it reflected in their academic records, particularly in the subjects in which they need to concentrate. As a result of their environment sensitivity, they may also have issues with attendance and health. Throughout the academic year, specifically Science, Mathematics, Arabic and English (with special emphasis on these objectives). As well as the absence reports accompanied by official medical excuses (if permitted); detailed reports on behavior (if permitted); and health records (for parents whose children have had health concerns reported); monthly questionnaires provided by the parents on the health, behavior, and mood of their children (if permitted); and psychological questionnaires administered toward the beginning and ending of the study (if permitted).

3.2.9 Resources required

There are four main requirements for conducting a research experiment in a school: (1) appropriate schools to serve as the experimental field - suitable teachers and students as research participants (2) suitable lighting equipment and staff - an opportunity for experimentation and analysis (3) human resources (students and staff) as well as experts in statistical and psychological analysis (if possible and not constrained by time or resources) and (4) equipment to measure, record, report, analyze, and generally conduct the experiment in a school. In addition, resources may have to be added if certain developments have been made in the plan or methodology that were not anticipated.

3.3 The methods and tools of data analysis

Statistical analysis will be the primary method of analysis. It is also desirable to conduct psychological analyses. However, this was not considered practical due to additional time, money, and experts to carry out these further analyses. A clear understanding of the results should be conveyed to the reader by stressing that what is expected from this analysis method is not simply the answer to the research question alone. The analysis will be more useful if it offers a path forward new questions, which then can be further studied, and in turn lead to a more discussion in detail regarding the optimal classroom lighting arrangements to facilitate the process of learning and teaching as well as prevent health problems. In order to better comprehend of the teachers' questionnaire results, as well as the students' answers, statistical analyses will be conducted and listed in tables and charts. In addition to comparing the results of the teacher questionnaires along with the teachers' opinions, the analysis of the questionnaires will reveal issues with health, student behavior during the school day, as well as the impact of lighting and ventilation on classroom conditions in both experimental schools.

Further discussion on data that is collected and analyzed will be presented in later sections of this study.

Iethodology	Study Objectives	Researchers	Publish Year
Lab experiment	It was observed that CCT and circadian lighting metrics of daylight in interior spaces differed considerably from those of artificial light when using a time-lapse high dynamic range image technique.	Sneha Jain1Luis Fernandes,Cynthia Regnier, Vishal Garg	2019
Mixed mode	For a typical classroom space, it is necessary to determine the size of the window to obtain an appropriate CS value.	Ignacio Acosta, Miguel Ángel, Russell Leslie, Leora Radetsky,	2019
	Research into whether it is possible to provide circadian stimulation to office spaces using LED lighting, while minimizing any additional energy consumption during the implementation of this scheme	C Jarboe , J Snyder and MG Figueiro	2019
	In their study, the researchers proposed an equation to demonstrate the relationship between corneal illuminance and daylighting design parameters such as WWR and surface reflectance.	Qi Yao , Wenjing Cai , Min Li , Zhiguo Hu , Peng Xue , Qi Dai	2020
	The purpose of this study was to learn how circadian effective light could affect the alertness of office workers during the working day	MG Figueiro , M Kalsher , BC Steversonc, J Heerwagen ,	2018

		K Kampschroerc and MS Rea	
Computer Simulation	Using WWR, surface reflectance, and latitudes can be used to estimate the percent of days in a year when a patient in a hospital room would receive a minimum CS value.	I Acosta, RP Leslie and MG Figueiro	2016
	Finding the optimal window size for four different positions in residential rooms in order to deliver the proper circadian stimulus	I. Acosta, J. F. Molina, and M. A. Campano	2017
Literature Review	The effect of the CS metrics on interior design is discussed in this essay	MS Rea and MG Figueiro	2016
	Discussion of the effects of exposure to light at night and what it does to the body	Mariana G. Figueiro	2017
	The purpose of this paper is to provide an overview of how light affects alertness and how it can be used to promote circadian entrainment.	MG Figueiro R Nagare and LLA Price	2017
Field Experiment	A study was conducted to determine whether daylight is effective in resetting the circadian rhythms of dementia care facilities during the peck time of the circadian resetting period.	Prof. Kyle Konis	2018

Table 2 - Comparison of different research methodologies (done by the author)

CHAPTER 4

4 THE EXPERIMENT

4.1 Climate condition

In the Middle East, the United Arab Emirates (Figure 4) is located near the tip of the Arabian Peninsula, with characteristic land-sea distribution associated with the coast of the Arabian Gulf, where the Tropic of Cancer passes through and a subtropical anticyclone is located over the top. In terms of latitude and longitude, it lies between 22° 50' and 26° North and 51° and 56° 25' East . All of these factors result in a tropical desert climate with several typical climatic characteristics. This country is a member of the Gulf Cooperation Council (GCC) with borders with Saudi Arabia, Oman, and Qatar. Total land area is approximately 83,600 square kilometers which is equivalent to 32,400 square miles. This country is located at latitude 25° 16' North and longitude 55° 16' East and overlooks the Arabian Gulf for a distance of 72 kilometers.

Figure 10 Map of the United Arab Emirates Source: http://www.persiangulfonline.org/maps.htm

As the United Arab Emirates has a hot and dry climate, there is not much rainfall, vegetation, and animal life. There are only a few mountains to be found throughout the

continent while there are a couple of islands off the coast of the Persian Gulf that are parts of the Persian Gulf Federation. A temperature range of 38°C to 48°C (100°F to 118°F) is experienced throughout the UAE during the summer months (April to September), whereas at night a temperature range of 26°C to 30°C (79°F to 86°F) with high humidity levels prevails. During the winter season, the weather is characterized by light precipitation and fog. In the winter months (October to March), there are many sunny days and warm nights, with average temperatures of 26°C (79°F) during the day and 15°C (59°F) at night.

In Figure 5, we can see the mean, maximum, minimum, and extreme temperatures for the period 1984-2001 provided by the Dubai International Airport (DIA) to the Department of Civil Aviation (DCA). Blue stripes represent the comfortable temperature zone, which is between 24 and 27°C. The red dashed line indicates the average maximum temperature while the green dashed line indicates the average minimum temperature.

Climate data for Sharjah [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	32.8 (90.5)	34.4 (93.9)	42.1 (107.8)	43.2 (109.8)	46.4 (115.5)	47.8 (118.0)	49.2 (120.6)	48.2 (118.8)	46.0 (114.8)	41.4 (106.5)	37.2 (99.0)	32.8 (91.0)	49.2 (120.6)
Average high °C (°F)	24.2 (75.6)	25.2 (77.4)	28.8 (83.8)	34.0 (93.2)	38.5 (101.3)	40.8 (105.4)	42.2 (108.0)	41.7 (107.1)	39.8 (103.6)	36.0 (96.8)	30.9 (87.6)	26.2 (79.2)	34.0 (93.3)
Daily mean °C (°F)	17.6 (63.7)	18.5 (65.3)	21.5 (70.7)	25.7 (78.3)	29.7 (85.5)	32.1 (89.8)	34.2 (93.6)	33.8 (92.8)	31.2 (88.2)	27.8 (82.0)	23.1 (73.6)	19.4 (66.9)	26.2 (79.2)
Average low °C (°F)	12.1 (53.8)	12.7 (54.9)	15.3 (59.5)	18.3 (64.9)	21.9 (71.4)	24.6 (76.3)	27.5 (81.5)	27.7 (81.9)	24.3 (75.7)	20.6 (69.1)	16.4 (61.5)	13.5 (56.3)	19.6 (67.2)
Record low °C (°F)	3.4 (38.1)	2.5 (36.5)	8.3 (46.9)	10.9 (51.6)	13.0 (55.4)	17.8 (64.0)	21.7 (71.1)	22.2 (72.0)	18.5 (65.3)	13.3 (55.9)	9.2 (48.6)	5.0 (41.0)	2.5 (36.5)
Average precipitation mm (inches)	9.5 (0.37)	34.8 (1.37)	33.0 (1.30)	7.5 (0.30)	1.4 (0.06)	0.5 (0.02)	0.1 (0.00)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	5.1 (0.20)	15.5 (0.61)	107.4 (4.23)
Average precipitation days (≥ 0.2 mm)	1.5	3.3	4.0	1.2	0.1	0.1	0.1	0.1	0.0	0.0	0.4	2.0	12.8
Average relative humidity (%)	69.0	68.0	64.0	56.0	51.0	56.0	54.0	57.0	62.0	64.0	64.0	69.0	61.2
Mean monthly sunshine hours	244.9	226.8	257.3	294.0	350.3	348.0	331.7	325.5	306.0	300.7	276.0	244.9	3,506.1

Figure 11 temperatures range

The orange line represents the average temperature range for each month. This information is similarly depicted in Figure 6. The average annual temperatures for the same period is depicted in Figure 7. An approximate temperature of 24-27°C is considered to be the thermal comfort zone. Each month's average temperature is shown in orange while green dashed lines represent the linear mean temperature for each month. In the same time period, Figure 8, represents the mean, the maximum, the minimum, and the extremes in humidity. On

the graph, the red dashed line represents the mean maximum, and as can be seen, it falls outside of the comfort zone. In figure 6, the green dashed line represents the mean minimum, and the orange line indicates the average humidity range over the course of each month.

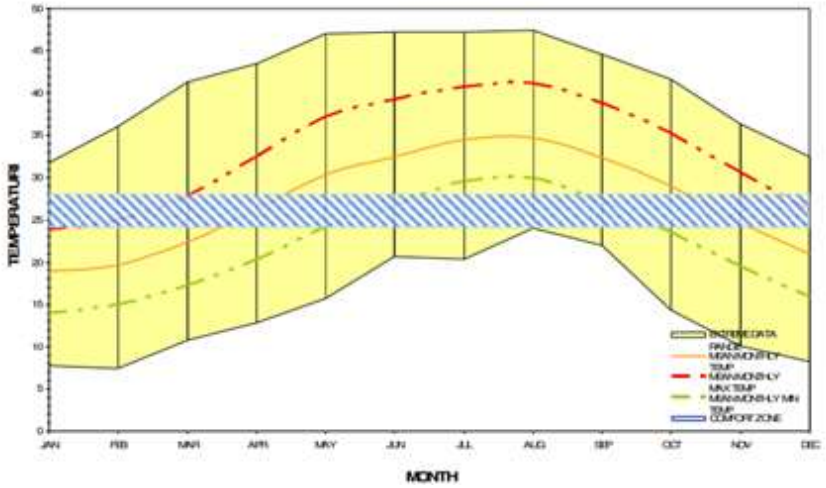

Figure 12 Mean, maximum, minimum, and extreme temperatures

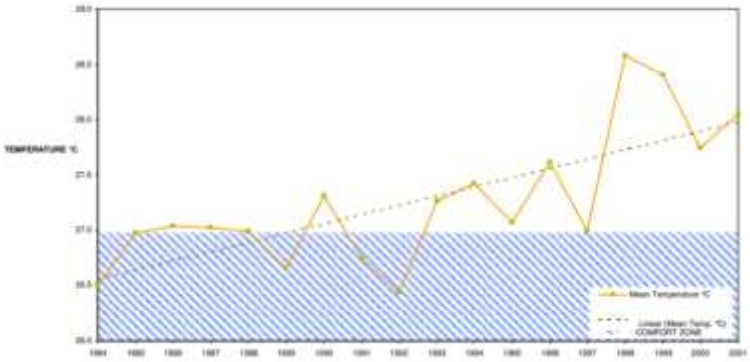

Figure 13 Average temperatures

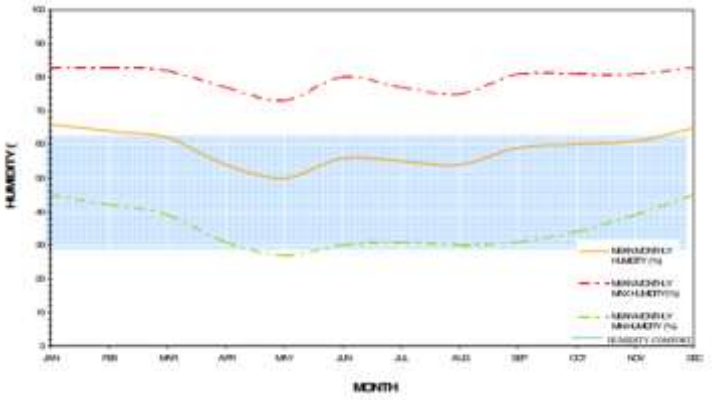

Figure 14 Mean, mean max, mean min and extreme humidity

According to the information obtained from the DCA and DIA, Dubai's sky type is predominantly clear year round. Figure 9, illustrates a graphic representation of the average monthly sunshine hours between 1974 and 2001. Based on the graph, the average number of hours of sunshine each day is between 7 and 11. During the month of December, the maximum number of sunshine hours recorded was 12 hours per day, while the minimum recorded number was 5 hours per day.

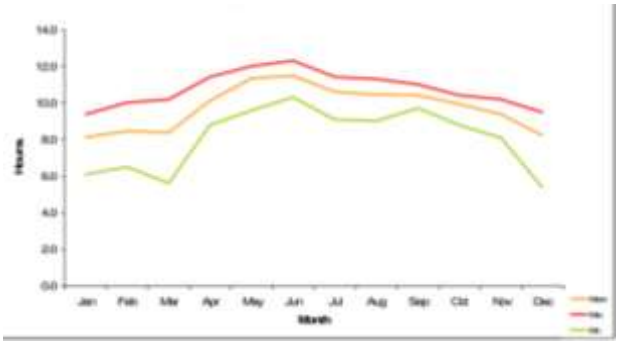

Figure 15 Average sunshine hours

4.2 Developing the experiment

In this experiment, three different classes at Victoria International School (VISS) in The Early Learning Center (ELC) in Sharjah, United Arab Emirates, are referred to as Classroom-A, Classroom-B and Classroom-C. This experiment took place in Early Learning Centre classrooms at the Victoria International School in Sharjah, UAE during the academic year

2020-2021, which is following the Australian curriculum. By comparing the effects of adequate daylight with those associated with full-spectrum, blue filtered fluorescent lighting and LED lighting, this chapter presents descriptions and explanations of the findings as guided by the research questions of the study. It critically examines the effects of full-spectrum, blue filtered fluorescent lighting and LED lighting on the process of learning in classrooms by comparing them with those associated with adequate daylight.

An academic year at Victoria International Private School is divided into three semesters, which start in September and end in June. These three semesters conclude at the end of December, March, and June respectively. Students are provided with grade reports at the end of each semester following the conclusion of the evaluation process. Using key performance indicators as metrics, the results of the analyses were used to measure the effectiveness and efficiency of the school. Based on a comprehensive review of online and offline sources, the key performance indicators have been developed. Based on the analysis, key performance indicators were used to evaluate the efficiency and effectiveness of the school. As a result of the study, a correlation between lighting and student performance will be determined and it is hoped that the findings will provide further insight into the decade-old question of unknown environmental influences. The school administration will be provided with guidance on how to best channel school resources towards improving students' visual comfort.

During the course of the study, 55 children from three classrooms of the early learning center of Victoria international school were recruited to participate in the study. Currently, there is a fluorescent lighting system installed in all classrooms that operates at a color temperature of 3000 K - 4000 K.

During the semester the kids were shifting between the three classes regularly and based on the teachers assessment of their react to the different types of their learning and playing time which include also drawing and following instructors instruction to analyze deeply how is the lighting effecting them in regards to how they are acting under each type of lighting here are the pictures of students while they were shifting during the day for different type of activity all over the semester.

In figure 16, 17, 18 and figure 19 the kids were in their everyday schedule which consist of Learning time, fine Motor skills, art and craft and drawing which is happening in the three classrooms with three different students group to analyze at the end of the semester in which class and which lighting type they were more calmed and following instructions and they were more energetic by comparing the assessment of the end of each week until the end of the semester.

Figure 16 Group A students in listening learning time

Figure 17 Group A students in Fine motor skills lesson

Figure 18 Group B students in art and craft lesson

Figure 19 Group B Students in drawing lessons

Children and their families were invited to participate in the survey during the Mother's Day morning tea event in figures 16 & 17 are some pictures taken for me during the event with my kids and with the other two parents who got to assist me to fulfill the survey during this event.

Figure 20 the author with the kids in the event of filling the survey

Figure 21 the author with the parent assisting in completing the surveys by kids before the event is over

A week prior to the event, parents of the participating children responded to an invitation sent via email through google forms and specifically approved their children to participate in it. With a response rate of 91%, 50 out of 55 recruited respondents completed the survey, which resulted in 52 out of 55 individuals completing the survey.

According to the survey, which was designed using google forms to determine perceptions, attitudes, and behaviors of children and their relationship to classroom lighting, seventeen questions were asked. Demographic information about the respondents, including their age and gender, was also requested. A survey was conducted among children with respect to images depicting a similar classroom equipped with fluorescent lamps (3000-4000K) compared with LED lamps (5000-6500K) and Full spectrum HD fluorescent (3500-5000K).

With the assistance of the children, each of the images was accompanied by a question asking them to choose which classroom they would prefer to be in for certain activities. There are many activities that may be considered desk activities, including reading at the desk, drawing and writing at the desk, taking a test at the desk, and sitting quietly at the desk. The children's emotional reactions to classroom images were also evaluated using a Likert scale with five choices, which included calm/excited, sleepy/awake, interested (interested but bored), safe (safe but anxious), and bored (bored). With regard to children aged five to six, facial emojis have been used to provide a way for them to accurately describe their feelings (such as calm, a little calm, neutral, a little excited, or excited). There was also a question regarding the child's preference for the type of activity they would prefer in a classroom lit by 5000K LED or Full spectrum HD fluorescent 5000K lighting rather than 3500K, with the options as 1) sit and listen, 2) move, 3) rest, and 4) none of the above. During the study, two questions were asked about the use of color and object clarity. Each image was exhibited using 5000K lamps, and each had a different color rendering index (CRI) (96 versus 85). Two studies were carried out in which three images were analyzed with Kelvin temperatures of 3500K, 5000K, and 6500K. According to the findings from the experiment, participants chose the image they perceived to be able to see color the best from among the different color renderings. The students also were asked to assess whether they perceived a change in light levels within the classroom through a five-point Likert scale, as well as the sounds emanating from the classroom. As well as the open-ended question, there was a space provided for respondents to provide their comments if they wished to. PREP teachers have reviewed and approved the survey before the survey is implemented so that the wording and comprehension are appropriate for the age group it is in. Students were asked to complete the survey by using either an iPad or laptop computer.

Furthermore, the findings of this study will be useful to future research students who wish to perform further studies on the same topic. It will enhance the researcher's knowledge of the impact of lighting on students in classrooms. Despite the fact that the number of students attending schools is on the rise and there is no visible change in the physical environment, it is imperative that these schools improve the academic performance of their students.

4.3 Observation of the Experimental Environment

4.3.1 Site analysis

Three different classes at Victoria International School (VISS) in The Early Learning Center (ELC) in Sharjah, United Arab Emirates, are referred to as Classroom-A, Classroom-B and Classroom-C. This experiment took place in Early Learning Centre classrooms at the Victoria International School in Sharjah, UAE during the academic year 2020-2021, which is following the Australian curriculum. In the figure 18 & figure 19, its showing the map location of the site in Sharjah, UAE and the sun path of the school.

Figure 22 school location map

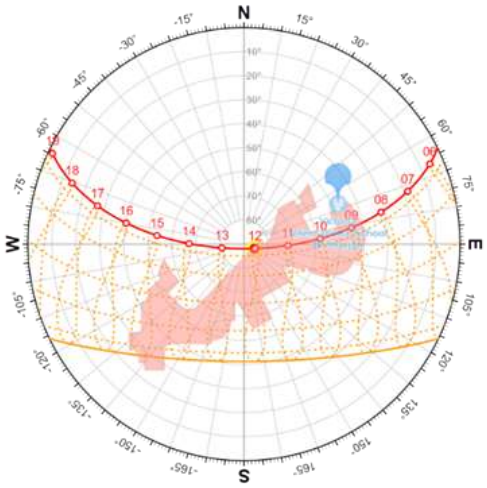

Figure 23 Location sun path

4.3.2 Classroom's interior and orientation

The VISS team strongly believes in the importance of even the smallest details. The campus was designed specifically to be able to accommodate three independent schools on the same site, so that it can support the three phases of child development simultaneously. The school is divided into three parts containing a primary school, an early childhood center, and a secondary school. All of the schools are equipped with modern classrooms and teaching technology. The environment in which children live has a profound impact on them. Accordingly, the ecological model supporting this Framework acknowledges the complexities of the lives of children within the social, environmental, economic, and political contexts see Figure 20. As illustrated in the model, a number of community services and programs support children's educational and developmental needs. As a central component of the Ecological Model, each child is unique, active, and devoted to their own growth and development within the context of their family, culture, and experience.

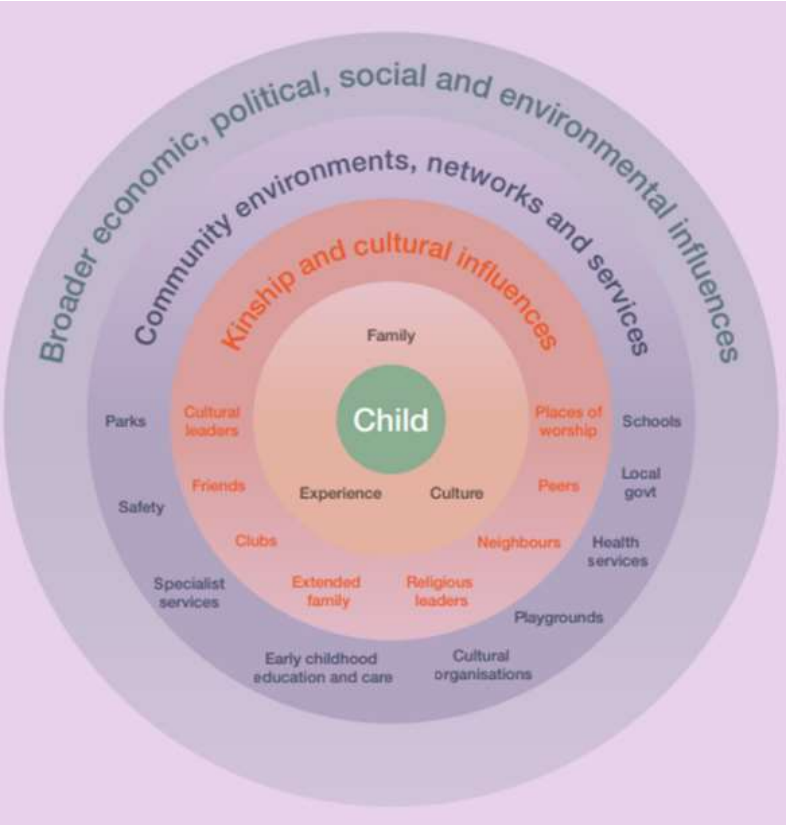

Figure 24 Ecological model source : (Bronfenbrenner, 1979)

In the classrooms, students are provided with a colorful environment accompanied by clustered desks. Each classroom consists of playing area and learning area since VISS follow a play-based curriculum, so they are having all open plan. the orientation of the classrooms openings was different and that's variations in the interior maximize the influence of lighting on the results and analysis, while minimizing the influence of other factors.

As seeing in figure 21, classroom-A follow the open plan with a dimensions of 19.0 m x 13.5 m. and the windows openings oriented toward Southwest and East-South East and having partition in between.

Figure 25 Classroom-A plan

The classrooms are having variety in regards the walls color and Classroom-A's walls are colored with green as seeing in the figure 22.

Figure 26 Classroom –A highlighted in green color

In classroom-B which following the open plan as well classroom it has a partition movable between two classes with windows opening oriented towards Northwest and North with a dimensions of each class is 13.0 m x 7.5 m which highlighted in figure 23.

Figure 27 Classroom-B plan

Classroom-B's walls as its showing the figure 24, are colored with greyish blue. With some yellowish wall arts and colorful floor carpet and grey vinyl flooring and having partition in between which divide the classroom as per the use of it.

Figure 28 Classroom –B highlighted in Grey color

In classroom-C As seeing in figure 25, the plan is following the open plan concept as well which having the learning time area and the playing time area with access to the outdoor play area from two glass door in different sides with a classroom dimensions of

13.0 m x 7.0 m. and the windows openings oriented toward South-Southwest and South-South East.

Figure 29 Classroom-C plan

As seeing in Figure26, the interior walls are varying between neutral 80% and one purple wall with indicates the kids toilets and the classroom is divided into two sections for learning and playing time while the white board are placed on the South direction beside the window.

Figure 30 Classroom –C highlighted in Purple color

4.3.3 Simulation for Lighting Study

- **Daylight analysis**

In figure 27, the daylight analysis using dialux evo software for classroom-A indicates the two orange area which means 1000-3000 lux are centered around the windows in the two sides while the others areas in the classroom are covered with variety of lux measure between blue to green which indicates 30-200 lux which are labeled on the floor plan in figure 27.

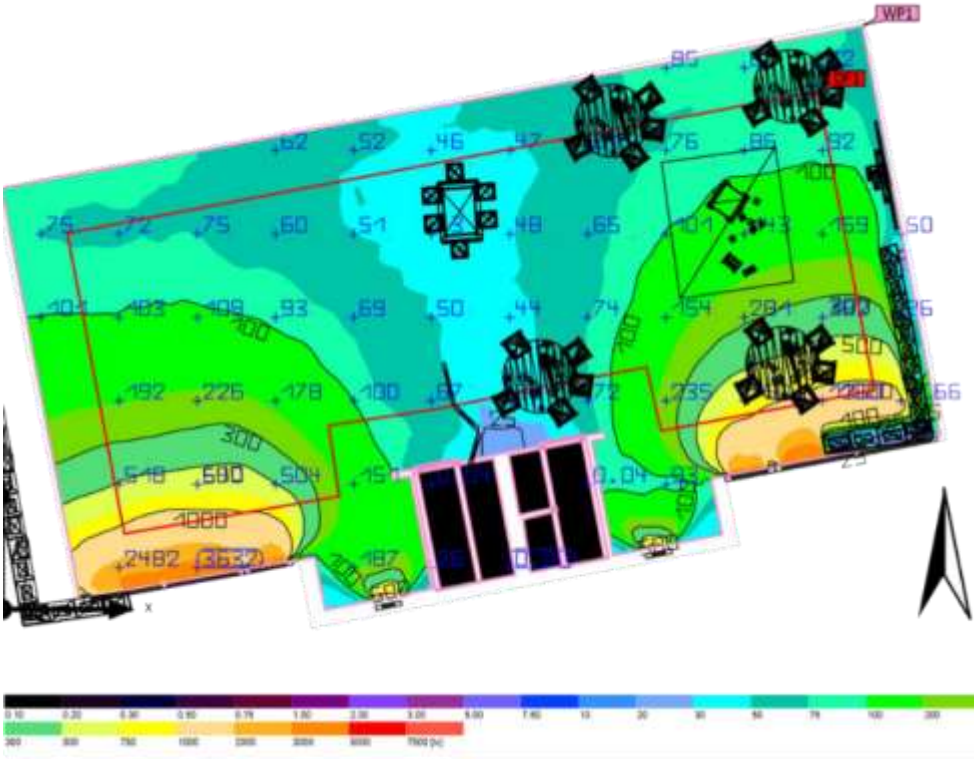

Figure 31 daylight analysis for classroom-A using DIALUX EVO top view

In the figure 28, which showing the daylight analysis in perspective view its showing that the green color which indicates the 100-300 lux are mostly covered the

classroom through the daylight only where its obvious that near to the windows its yellow color which indicates 750 lux as its showing in the perspective view of the daylight analysis.

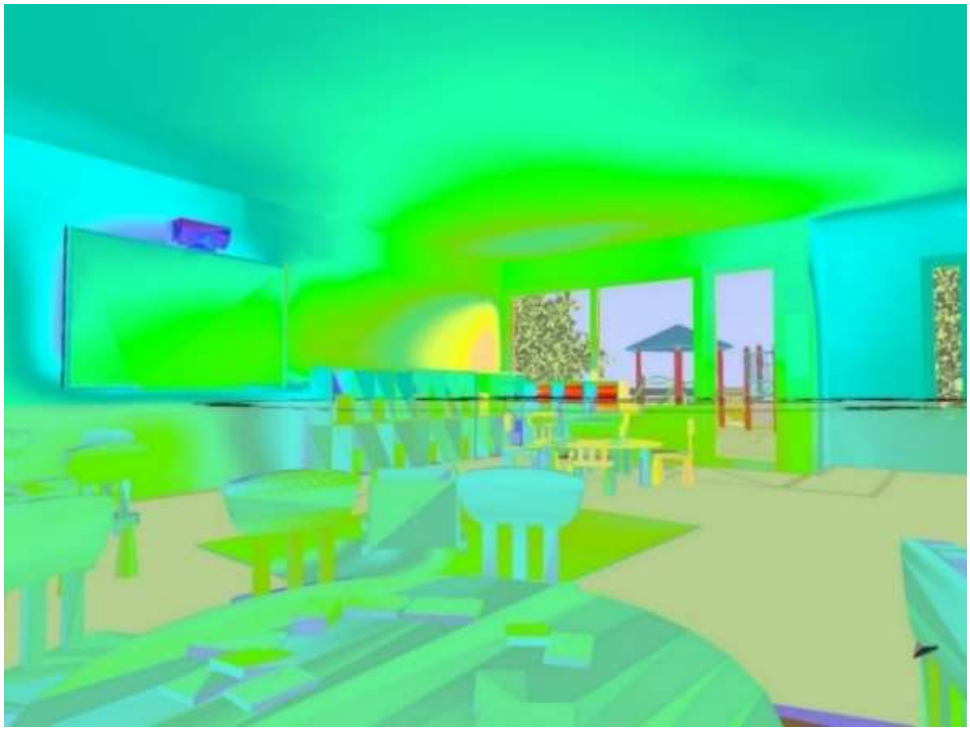

Figure 32 daylight analysis for classroom-A using DIALUX EVO perspective view

In classroom-B in figure 29, its indicating the lux level variety for the daylight analysis which varies between the yellow color to the dark green which means 200 – 2000 lux and its different from classroom-A as its having skylight and more opening and its orientation as its indicated in figure 30 and 31, how the red color is surrounding the skylights area.

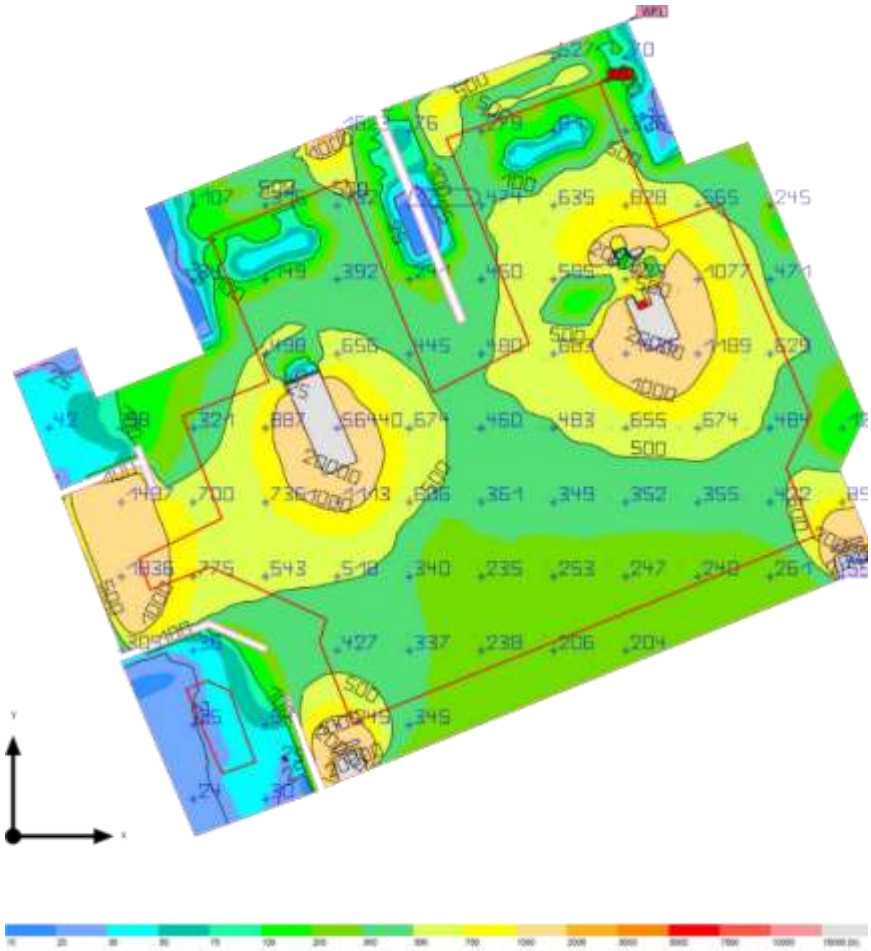

Figure 33 daylight analysis for classroom-B using DIALUX EVO top view

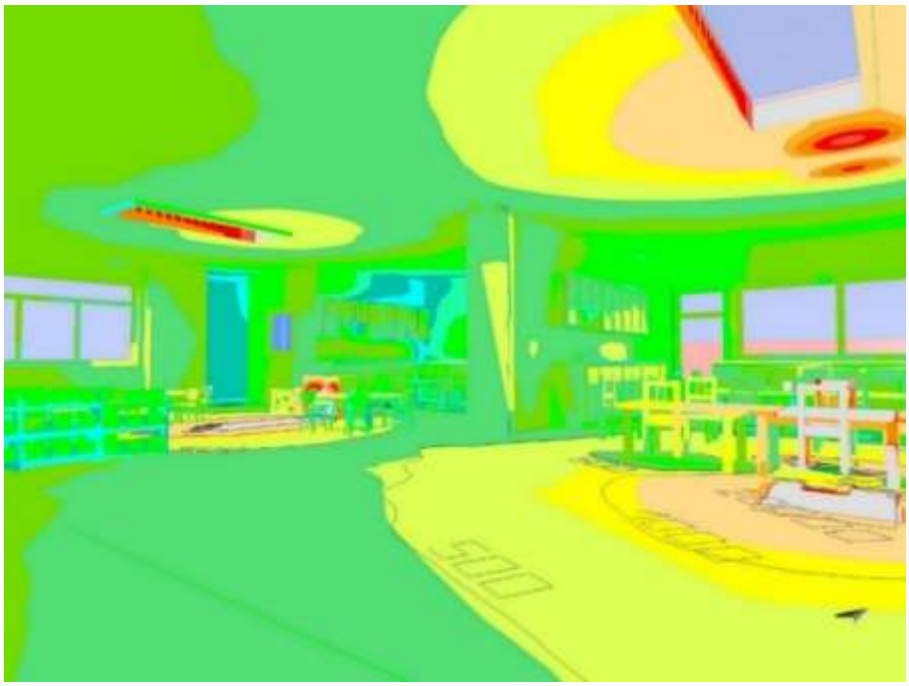

Figure 34 daylight analysis for classroom-B using DIALUX EVO perspective view

Figures 31 and 32 illustrate the daylight analysis for classroom C, which has only one skylight, while the yellowish-orange shading surrounds the area of the skylight, which is the area of the classroom that receives the most daylight during the day.

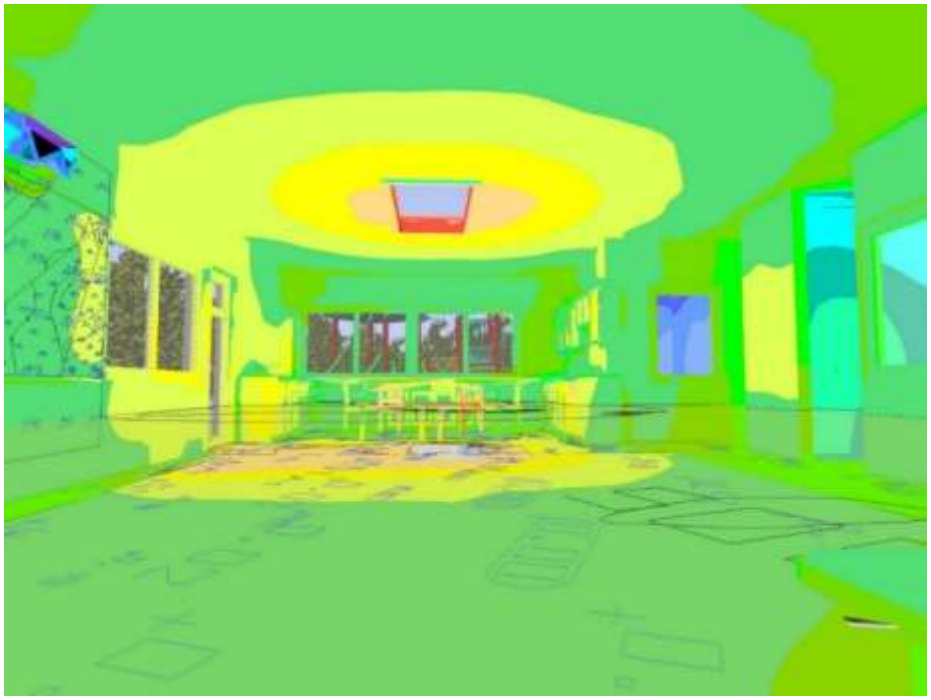

Figure 35 daylight analysis for classroom-C using DIALUX EVO perspective view

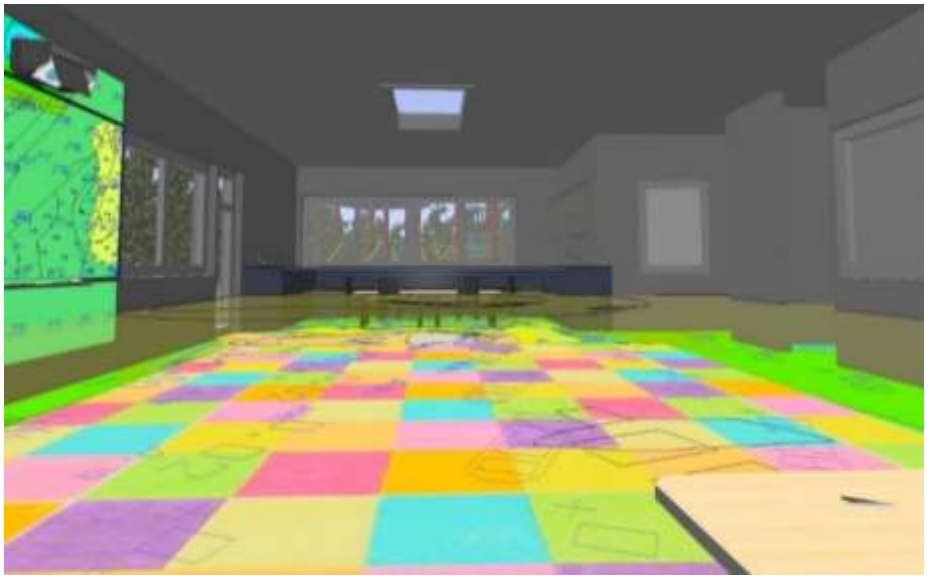

Figure 36 daylight textures for classroom-C using DIALUX EVO perspective view

- **Artificial lighting**

There are two main factors that determine the color of a fluorescent tube - the correlated color temperature (CCT) and the color rendering index (CRI). As far as the color temperature of fluorescent tubes is concerned, a lot of personal preference plays a role in the decision. A professional environment is usually created by using cool colors (e.g., in offices, classrooms, retail stores), and a comfortable environment is usually created with warm colors (e.g., in hotels and in residential areas) (Karlen and Benya, 2004).

Figure 37 lighting color temperature

The artificial lighting in classroom-A is controlled by a single switch. The fluorescent tubes used are cool white Osram tubes, and they are partially covered with a diffuser as shown in Figure 34.

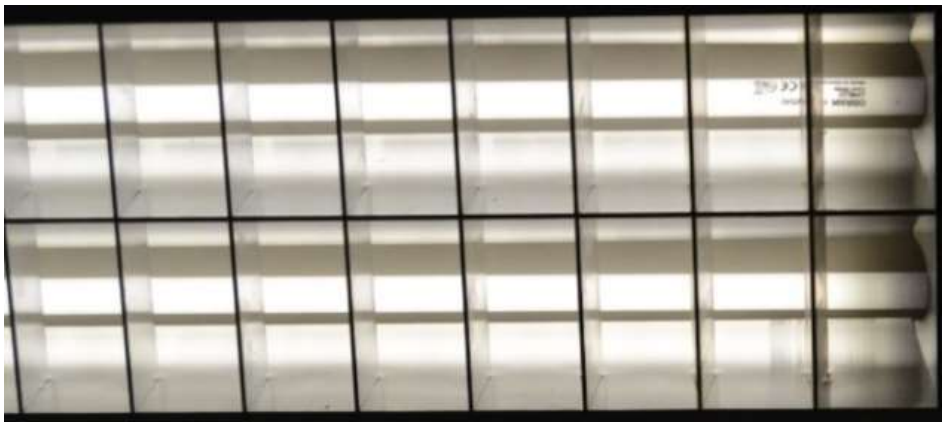

Figure 38 the artificial light used in Classroom-A

Figure 39 image taken showing the light distribution in classroom-A

Figure 36, shows a symmetrical distribution of lights in classroom-A, which is indicated by the yellow shading and by the blue shading for daylight access windows.

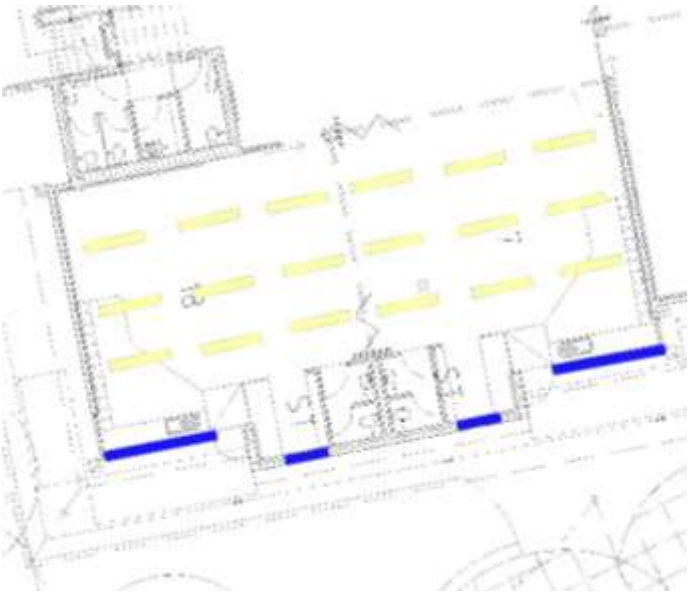

Figure 40 top view for classroom-A

Figure 41 light distribution curve for classroom-A

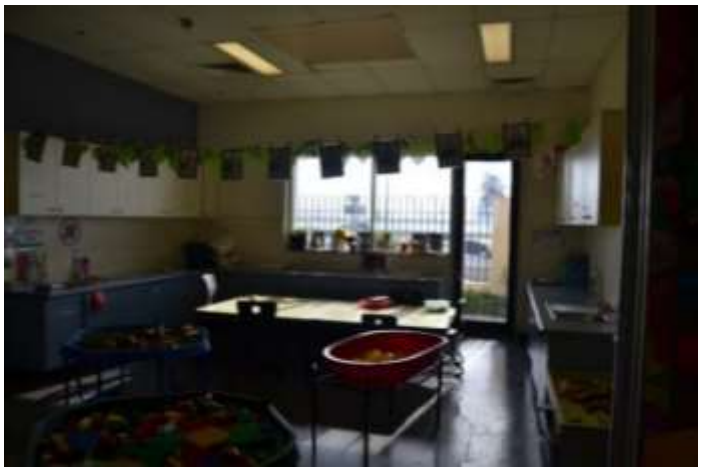

Figure 42 photo taken showing the light distribution in classroom-B

However, in Classroom-B there were two types of lighting. The first type, shown in figure, is LED lighting. The second type, Philips fluorescent tubes are shown in figure, with two different color light sources. Furthermore, the distribution of light is not evenly distributed as can be seen in the figure 39, which has also been highlighted in yellow, while the blue indicates an opening for daylight.

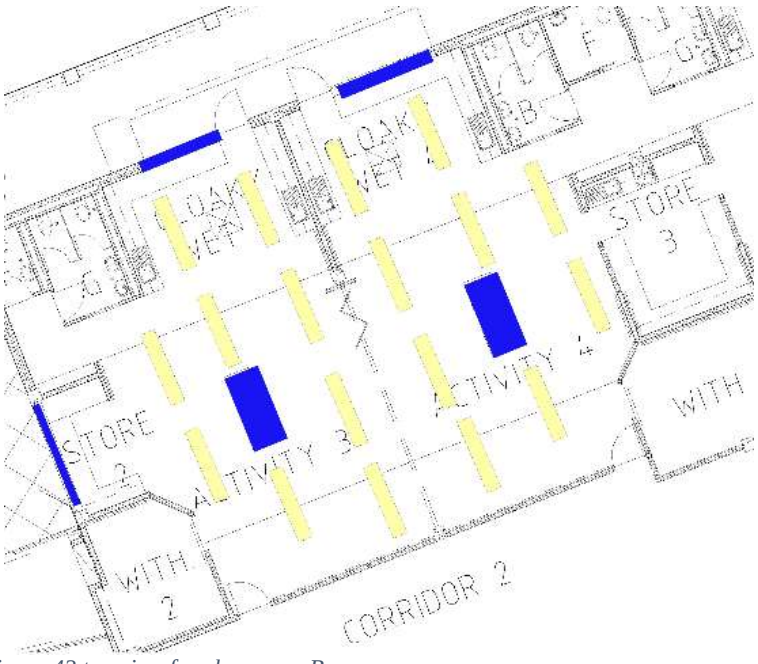

Figure 43 top view for classroom-B

Figure 44 light distribution curve for classroom-B

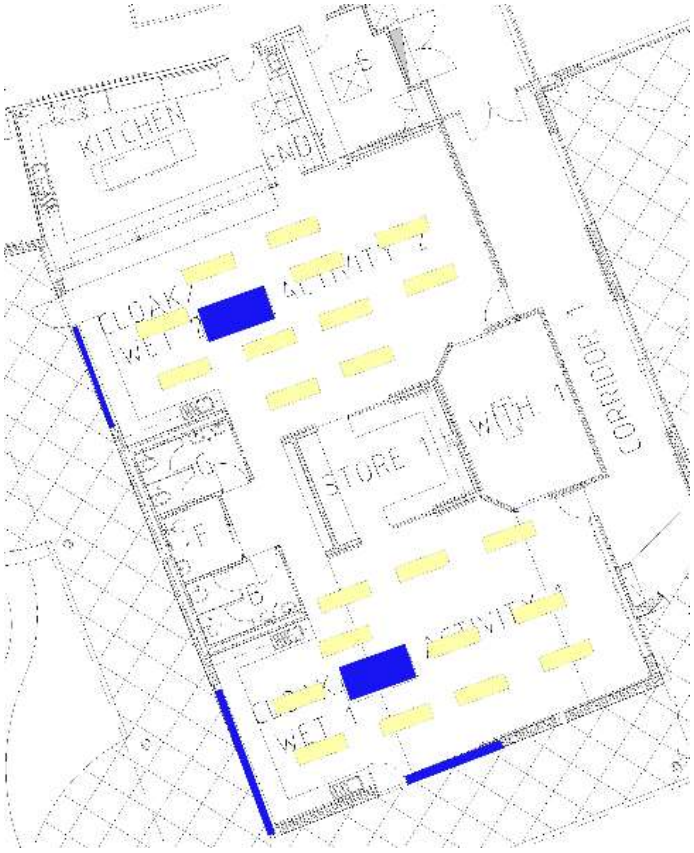

Figure 45 top view for classroom-C

Figure 41. shows the way fluorescent lights are distributed with the yellow color and the skylights and windows are highlighted with blue indicating that they are oriented toward the South-Southwest and South-South East respectively.

Figure 46 image taken showing the light distribution in classroom-C

4.4 Summary

Parameter	Classroom-A	Classroom-B	Classroom-C
Operation time	8:00 am – 4:00 pm		
Period of observations	End of semester evaluation to be compared to previous semester evaluation and kids to answer the surveys		
Grade	PREP	FS2	FS1
Duration	One semester		
Interior scheme	Green interior wall	Greyish blue interior wall	Neutral interior walls
Luminaire distribution	Symmetrical	Asymmetrical	Asymmetrical
Daylight orientation	South West and East-South East	North West and North	South-South West and

			South-South East
Existing lighting	Fluorescent	LED & Fluorescent	Fluorescent
Experiment rotation	Full spectrum fluorescent (3500-5000K)	LED (5000-6500)	Fluorescent (3000-4000)

Table 3 - Summary of the experiment (done by the author)

In table 4, its summarizing the simulation that have done using DIALUX EVO, under different lighting conditions to calculate the differences in regards to lux measurements and consumptions and the lighting measurements have been taken in-site too using CENTER LIGHTMETER as showing in table 5, to compare them.

			classroom-A (Fluorescent)	Classroom-B (LED)	Classroom-C (Full spectrum Fluorescent)
visual task area	Task area	Before	734 lx	706 lx	1266 lx
		After	710 lx	695 lx	1276 lx
	Surrounding	Before	60.4 lx	335 lx	6387 lx
		After	57.3 lx	329 lx	6373 lx
	Background	Before	79.4 lx	223 lx	1501 lx
		After	82.0 lx	208 lx	1499 lx
consumption	Value	Before	[2400 - 3400] kWh/a	[1050 - 1650] kWh/a	[580 - 910] kWh/a
		After	1850 - 2700] kWh/a	770 - 1200] kWh/a	[380 - 590] kWh/a

	Cost	Before	[721 - 1013] €/a	[316 - 490] €/a	[174 - 272] €/a
		After	[548 - 817] €/a	[232 - 359] €/a	[113 - 176] €/a
calculation surface	Perpendicular plane	Before	701 lx	614 lx	1183 lx
		After	678 lx	602 lx	1195 lx
	Vertical plane	Before	297 lx	468 lx	1186 lx
		After	294 lx	471 lx	1010 lx
	Horizontal plane	Before	702 lx	615 lx	1013 lx
		After	679 lx	603 lx	1198 lx
working plane		Before	655 lx	824 lx	1672 lx
		After	633 lx	813 LX	1673 lx

Table 4 - summary of simulation (done by author)

	CLASSROOM-A	CLASSROOM-B	CLASSROOM-C
BEFORE			

			
AFTER			

Table 5 - In-site measurements (done by author)

5 ANALYSIS AND DISCUSSION

5.1 Illumination and Activity

Children were asked to select their preferred picture to illustrate specific activities that could be performed under LED, fluorescent and full spectrum fluorescent lighting. Compared to the fluorescent image of 3500K and 5000K full spectrum fluorescent the LED image of 6000K was chosen more frequently by participants for several tasks, including reading at their desk (58%), while for drawing and writing preferred by (64%), and taking tests (54%). although seated at a desk and seated quietly were more likely to prefer full spectrum fluorescent 5000K (65%).

I enjoy reading at my desk most in this room	
LIGHT SOURCE	**%**

LED 6000K	58%
FLUOR 3500	10%
FULL SPECTRUM FLUORESCENT 5000K	32%
	100%
I enjoy taking tests in this room the most.	
LIGHT SOURCE	**%**
LED 6000K	54%
FLUOR 3500	31%
FULL SPECTRUM FLUORESCENT 5000K	15%
TOTAL	100%
Drawing and writing are my favorite activities in this room	
LIGHT SOURCE	**%**
LED 6000K	64%
FLUOR 3500	23%
FULL SPECTRUM FLUORESCENT 5000K	13%
TOTAL	100%
The room I prefer for sitting quietly at my desk is this one	
LIGHT SOURCE	**%**
LED 6000K	21%
FLUOR 3500	14%
FULL SPECTRUM FLUORESCENT 5000K	65%
TOTAL	100%

Table 6 - students Questioners results regard lighting and activity (done by the author)

5.2 Illumination and Emotion

Various studies conducted by (Sleegers, et al., and Mott, et al. 2012) find that different kelvin temperatures correspond with different emotions, such as alertness, focus, and arousal; bluer and higher kelvin temperatures indicate the opposite. A series of four pictures shown in a classroom were arranged in an alternating order with different temperatures in Kelvin and Children were asked to rate the intensity of their emotions in relation to the temperature. In a test in which participants were provided with 5000K full spectrum fluorescent lamps, 42 % of them indicated that they felt more alert/focused rather than bored/distracted by the lights. Also, depending on where you asked 3500Ks about their feelings of calm in the classroom (31 %)

and about how they felt about the level of excitement in class (15%) there were significant differences in the level of reaction. An image which depicts 3500K showed an interesting contrast between the feeling of calmness and feeling of excitement, with a relatively small percentage (24%) of respondents indicating a feeling of calmness. The results of the classroom depicting 6000K assessing tired (10% tired - 35% a little tired) rather than alert (31% alert, 25% a little alert) were mixed. Refer to Table 7.

lighting and emotions					
Is there anything I feel when I look at the classroom in the picture?					
LED 6000K	tired	a little tired	neither	a little alert	alert
	15%	12%	17%	25%	31%
FLUOR 3500	Calm	A Little Calm	Neither	A little excieted	Exceited
	31%	8%	25%	21%	15%
FULL SPECTRUM FLUORESCENT 5000K	focused	a little alert	neither	distracted	board
	42%	19%	15%	12%	12%

Table 7 - students Questioners results regard lighting and emotions (done by the author)

5.3 Illumination and Behavior

LED 6000K, Fluorescent 3500K and full spectrum HD fluorescent 5000K were used in three classrooms to demonstrate how a child would perceive the different light sources and the resulting behavior. The behavior options were: 1. Listen attentively (LED 54%, Fluorescent 40%, Full spectrum 42%); 2. move and talk (LED 37%, Fluorescent 33 %, Full spectrum 19%); 3. get my head down and sleep (LED 23%, Fluorescent 10%, Full spectrum 18%); 4. None of the mentioned (LED 29 %, Fluorescent 17%, Full spectrum 19%). See Table 8.

Lighting and behavior				
It makes me wish to be in that classroom to				
	Listen attentively	Move and talk	get my head down and sleep	None of the mentioned

LED 6000K	54%	37%	23%	29%
FLUOR 3500	40%	33%	10%	17%
FULL SPECTRUM FLUORESCENT 5000K	42%	19%	18%	19%

Table 8 - Students questioners results regard lighting and behavior (done by the author)

5.4 Light and Object Acuity

Using the same Kelvin temperature of 6000K, the same image showing the primary colors with varying color rendering indices. Among the two images, first one with a CRI of 96 and the second had a CRI of 85. In the first image CRI 96 (67%) the participants rated seeing the colors more clearly than in the second image CRI 85 (33%). Three different CCTs were used to evaluate the visual clarity of objects: 3500K, 6000K, and 5000K. Moreover, 48% of participants selected the 6000K image as one of the most clearly recognizable objects. As shown in Table 9.

Lighting & Acuity of Color and Objects		
Which picture provides a better view of the objects?		
light source	**%**	**count**
5000 CRI 96	67%	31
5000 CRI 85	33%	21
total	100%	52
LED 6000K	48%	25
FLUOR 3500	19%	10
FULL SPECTRUM FLUORESCENT 5000K	33%	17
TOTAL	100%	52

Table 9 - Students questioners results regard lighting and acuity (done by the author)

5.5 Illumination and Sounds

There have been complaints about the humming or buzzing sound produced by fluorescent lamps due to their ballasts. In a survey, students A survey was conducted to determine if their classroom lights produce a humming or buzzing sound and if the sound is uncomfortable for them. An overall mixed response was obtained in terms of agreeing to disagreeing, with no significant impact of lighting on the perception of sounds. Table 10 illustrates this.

Lighting and Sounds					
Occasionally there is a buzzing or humming sound in my classroom caused by the lights.					
YES	Maybe yes	Neither yes nor no	I think no	NO	Don't know
38%	13%	15%	17%	4%	13%

Table 10 - Students questioners results regard lighting and sounds (done by the author)

5.6 Illumination and flickering

The flickering of fluorescent and LED lamps is a common problem. However, there was no meaningful response regarding whether the survey respondents yes (maybe yes/yes, 37%) or no (I think no, 19%). See Table 11.

Lighting and Flicker					
As the teacher turns on the lights in my classroom, the lights flicker.					
yes	Maybe yes	Neither yes nor no	I think no	no	Don't know
27%	10%	19%	9%	10%	25%

Table 11 - Students questioners results regard lighting and flicker (done by the author)

There has been a lot of research that shows that children's behavior can be affected by the amount of light in a room. This is where teachers use light as a tool of enhancing the

performance of children. A further analysis of the survey also showed that there was little agreement (17%) or disagreement (10%) among respondents about whether their teachers lower or raise the light level throughout the day in their class. However, that most of the respondents agreed (40%) and partly agreed (17%) that they like it when the light level in the classroom is changed, See Table 12.

Light Levels in Classroom					
During different times of the school day, the teacher alters my classroom's light levels.					
agree	agree a little	Neither agree nor disagree	Disagree a little	Disagree	Don't know
32%	17%	15%	9%	10%	17%
Whenever the teacher adjusts the brightness of the light in the classroom, I find it enjoyable					
agree	agree a little	Neither agree nor disagree	Disagree a little	Disagree	Don't know
40%	17%	13%	9%	8%	13%

Table 12 - Students questioners results regard lights levels (done by the author)

CHAPTER 5

CONCLUSION AND RECCOMENDATIONS

The purpose of this study was to review the literature and collect data on the perceptions of children's emotions, mental attitudes, as well as their behaviors related to classroom lighting. Children who were tasked with tasks that required concentration chose lighting that was 6000K LED on average over FLUOR 3500 and full spectrum 5000K. Researchers have concluded that this survey's outcome is similar to that of past studies (Sleeger, et al, 2012) where LEDs with higher correlated color temperatures are found to be particularly effective in increasing attention during certain activities, including reading, drawing, writing, and taking tests. Several of the lighting conditions had mixed effects on the moods or feelings of calm/excitement (3500K) and sleepy/awake (6000K). The effect of CCT over 5000 K is more determined by a person's psychological fatigue levels as well as how they react to the degree of blue-bright light in the environment. (Smolders and Kort,2016) found the most significant correlation between the CCT of 6000K and the highest image CCT in their article. In the 5000K classrooms, the majority of the pupils reported feeling alert and focused while in the 3500K classrooms, they felt more relaxed and safe. The results of this study support that dynamic or adjustable lighting can have a beneficial effect not only on the behavior of children, but also on their academic performance in the classroom. In contrast, fluorescent 3500K had a mixed response, with the majority of children preferring the LED 6000K classroom unless they were seated or listening.

There is a possibility that the results in 3500K's classroom are affected by the wide windows in the classrooms and skylight. While 6000K's classroom had windows as well, but daylight was not introduced. This question may not be an accurate representation of the impact of CCT on human

behavior as suggested by several studies that have demonstrated daylight can also affect our behavior (Govén, et al, 2009). In a study by (Veitch and McColl,2001) it was discovered that children perceive higher CCT and CRI images as giving them a better appreciation of color details and objects in general. When it came to their attitudes toward sounds and flickering, the children's perception of these elements was mixed and not significant. Depending upon the participant's age, their level of memory ability, and the nature of the schools where they were recruited, it may be the result of all or a combination of these factors. It should be noted that despite these concerns the majority of children stated that they enjoyed the change in light levels. This concept needs to be understood in deeper detail in order to determine if perceived attitude and behavior are influenced by the amount of light or by the color temperature. Several previous studies and research have indicated that a variety of illumination sources and light temperatures have the potential to influence human perception, cognition, behavior, and attitudes.

This survey confirms many of those findings relating to alertness, focus, and attention, as well as a few others. While these attitudes and perceptions are observed in both-singles and paired samples, there are some limitations due to the fact that they are self-reports. In order to gain a more comprehensive understanding of the effects of LED lighting in comparison to fluorescent lighting in the classroom, further research and other methodologies are required. In addition, there is a paucity of empirical studies on tunable or dynamic lighting, which may explain their effectiveness in learning environments, especially in the classroom. Additional research is needed to test whether they are economically feasible to implement.

A person's behavior, performance, and well-being can be strongly affected by the types of lighting they are exposed to. There have been several studies investigating how fluorescent and

LED lighting inside classrooms and workplaces contributes to the success of these areas (Smolder and de Kort,2014). The findings of this study revealed that in response to the results of this study, the most significant finding indicated that kids perceived higher Kelvin LED light to be more beneficial to aiding them in focusing, sustaining alertness, and being able to work effectively at their desk. Results of the study were mixed in terms of emotion perception, sound perception, and the perception of flickering. As a result of a number of limitations, this study is neither comprehensive nor comprehensive. This is because the participants were recruited from diverse schools and that their perceptions of the school were reported by the students themselves. It is critical to conduct future research in a controlled environment at schools, to understand the effects of dynamic and programmable lighting on students and teachers. This is also important to observe the behavior and development of children. I believe that it is absolutely crucial to determine how lighting affects the behavior of students in the classroom, as well as their physical, psychological, and cognitive needs, and to monitor the positive effects that lighting has on their behavior, attitudes, and performance. Some ideas and concepts were intended to be applied but could not be done due to several factors (including ethical restrictions, time constraints and financial constraints,).

There have been several other general findings discovered as part of this experiment. First and foremost, classrooms should be spacious and not overcrowded for better performance. As a second recommendation, elementary classrooms should have a balanced color scheme in order to prevent them from becoming too neutral or too bright. In order to improve daylight access, it is recommended that classrooms and buildings have windows that are of sufficient size and that can be opened and closed from the east rather than the west. In conclusion, Physical Education has been shown to be an important subject that can influence the performance of other subjects.

A more in-depth analysis of the results is essential in order to understand the results. It is suggested that similar studies focusing on these factors be commissioned in the future. In determining the students' performance in school, a variety of factors are considered, including: health records of the teacher and the student, absences due to illness, behavior assessment, teachers' comments on the students' moods, and psychological factors.

The following topics should be investigated further for further research and analysis: - Enhanced illumination may be achieved through the use of LED lights combined with task lighting or another color of artificial light. An examination of the factors that affect retractable results to determine if they would work optimally in various lighting conditions is necessary. Incorporating fluorescent and LED lighting to determine health effects, comparing the results of converting lighting to dynamic lighting in different settings (commercial and residential).

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APPENDICES

I. Appendix A: Questionnaire

1. **what is your age?**

   4 - 5 years

   6 - 7 years

2. **what is your gender**

   BOY

   GIRL

3. **I enjoy reading at my desk most in this room.**

Option 1

Option 2

Option 3

4. **Drawing and writing are my favorite activities in this room**

Option 1

Option 2

Option 3

5. **I enjoy taking tests in this room the most.**

Option 1

Option 2

Option 3

6. **The room I prefer for sitting quietly at my desk is**

Option 1

Option 2

Option 3

7. **Is there anything I feel when I look at the classroom in the picture?**

CALM
A LITTLE CLAM
NEITHER
A LITTLE EXCITED
EXCITED

8. **Is there anything I feel when I look at the classroom in the picture?**

SLEEPY
A LITTLE SLEEPY
NEITHER
A LITTLE AWAKE
AWAKE

9. **Is there anything I feel when I look at the classroom in the picture?**

FOUCSED
A LITTLE FOUCSED
NEITHER
A LITTLE BOARED
BOARED

10. **Is there anything I feel when I look at the classroom in the picture?**

SAFE
A LITTLE SAFE
NEITHER
A LITTLE WORRIED

WORRIED

11. **It makes me wish to be in that classroom to**

LISTEN WITH ATTENTION
MOVING AND TALKING SLEEPY
NONE

12. **It makes me wish to be in that classroom to**

LISTEN WITH ATTENTION
MOVING AND TALKING SLEEPY
NONE

13. **Which picture provides a better view of the objects?**

Option 1 Option 2

14. **Occasionally there is a buzzing or humming sound in my classroom caused bythe lights.**

YES
MAYBE YES
NEITHER
I THINK NO
NO
I DON'T KNOW

15. **As the teacher turns on the lights in my classroom, the lights flicker.**

YES
MAYBE YES
NEITHER
I THINK NO
NO
I DON'T KNOW

16. **During different times of the school day, my teacher alters the levels of light inmy classroom.**

YES
MAYBE YES
NEITHER
I THINK NO
NO
I DON'T KNOW

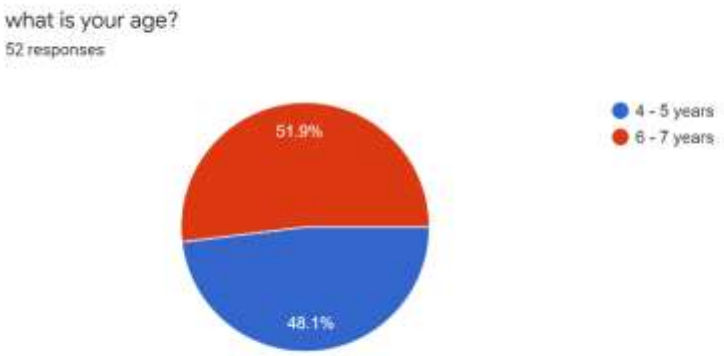
17. **I enjoy it when the teacher changes the brightness of the light in classroom.**

YES
MAYBE YES
NEITHER
I THINK NO
NO
I DON'T KNOW

18. **Are there any other details you would like to share about the lighting in yourclassroom and how it affects your behavior and feelings?**

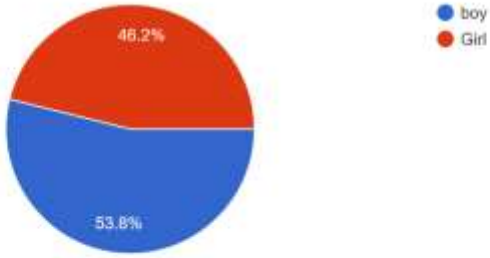
I feel more alert and awake when it is bright out.
I like it when it is dark
I am annoyed by the lighting in my classroom
It appears as if there are dots in front of my face when lights turns on
My classroom has an excessive amount of light, and I do not like it

II. Appendix B: Survey results



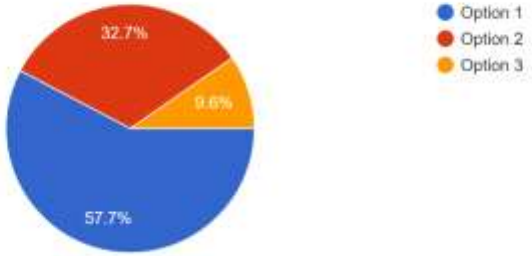
what is your gender

52 responses



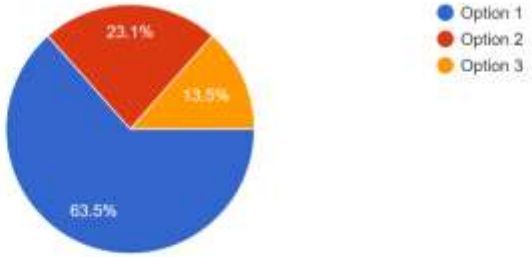
I enjoy reading at my desk most in this room

52 responses



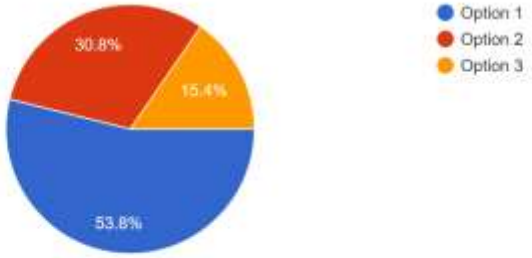
Drawing and writing are my favorite activities in this room

52 responses



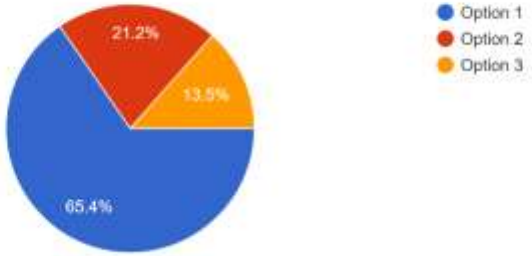
I enjoy taking tests in this room the most.

52 responses



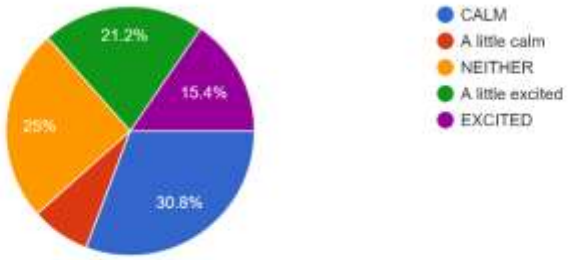
The room I prefer for sitting quietly at my desk is

52 responses



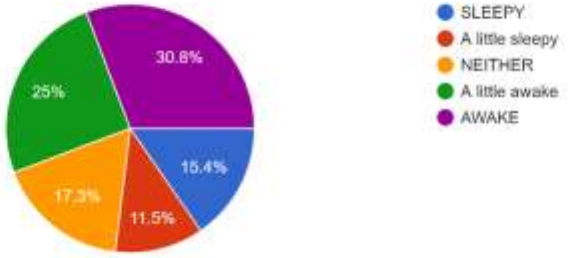
Is there anything I feel when I look at the classroom in the picture?

52 responses



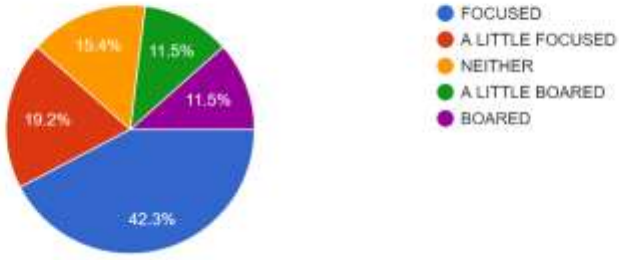
Is there anything I feel when I look at the classroom in the picture?

52 responses



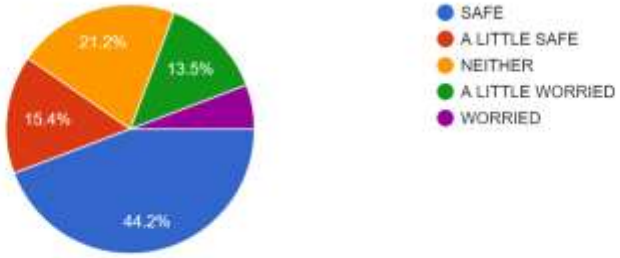
Is there anything I feel when I look at the classroom in the picture?

52 responses



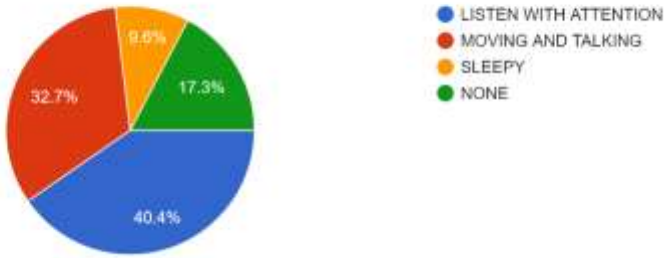
Is there anything I feel when I look at the classroom in the picture?

52 responses



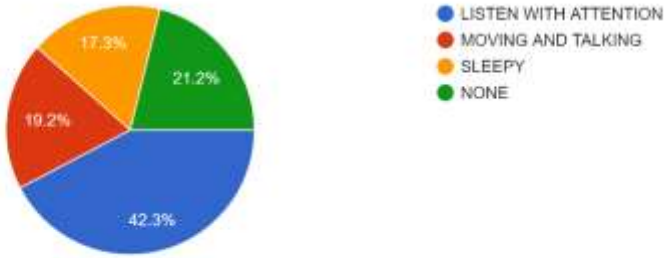
It makes me wish to be in that classroom to

52 responses



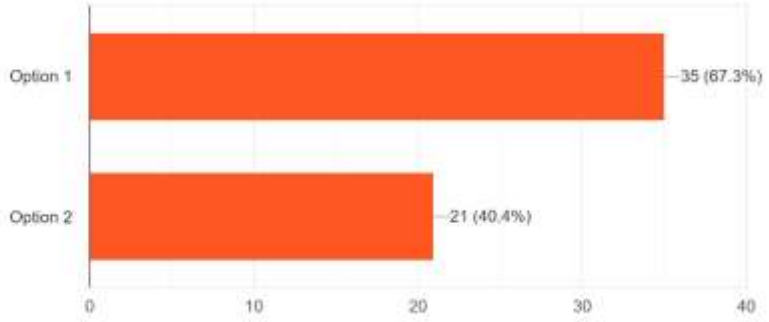
It makes me wish to be in that classroom to

52 responses



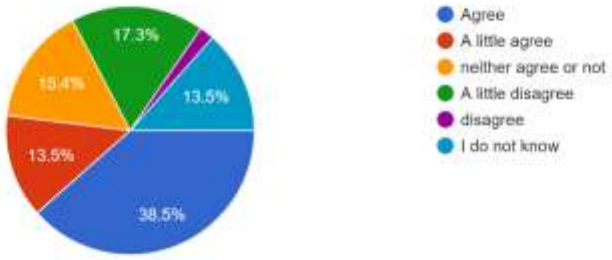
Which picture provides a better view of the objects?

52 responses



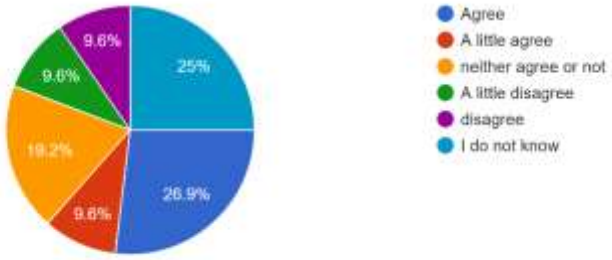
Occasionally there is a buzzing or humming sound in my classroom caused by the lights.

52 responses

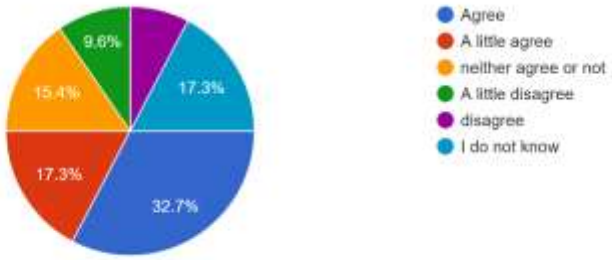


As the teacher turns on the lights in my classroom, the lights flicker.

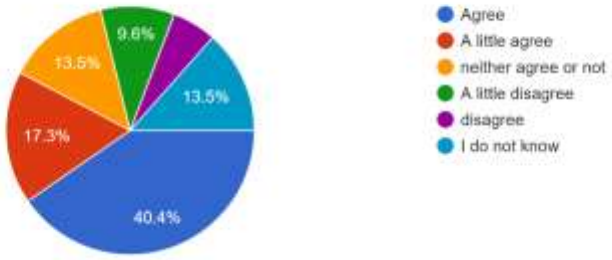
52 responses



During different times of the school day, my teacher alters the levels of light in my classroom.
52 responses



I enjoy it when the teacher changes the brightness of the light in classroom.
52 responses



Are there any other details you would like to share about the lighting in your classroom and how it affects your behavior and feelings?
52 responses